This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

551.79
K33
Stanford University Library

pam

Cat

Prof. J. C. Branner with the respect of the author

ON THE

GLACIAL GEOLOGY

OF THE

ISLE OF MAN,

BY

PERCY F. KENDALL, F.G.S.,

LECTURER ON GEOLOGY AT THE YORKSHIRE COLLEGE,
LEEDS.

EXTRACTED FROM YN LIOAR MANNINAGH,
THE JOURNAL OF THE ISLE OF MAN NATURAL HISTORY AND ANTIQUARIAN SOCIETY
VOL. I, NO. 12 (OCTOBER, 1894), p. 397.

ISLE OF MAN:
BROWN AND SON, PRINTERS, TIMES BUILDINGS, ATHOL STREET, DOUGLAS.
MDCCCXCIV.

551.79 K33

he Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY

he

LE

ON THE

GLACIAL GEOLOGY

OF THE

ISLE OF MAN,

BY

PERCY F. KENDALL, F.G.S.,

LECTURER ON GEOLOGY AT THE YORKSHIRE COLLEGE,
LEEDS.

Extracted from Yn Lioar Manninagh,
The Journal of the Isle of Man Natural History and Antiquarian Society,
Vol. 1, No. 12 (October, 1894), p. 397.

ISLE OF MAN:
Brown and Son, Printers, Times Buildings, Athol Street, Dodglas.
MDCCCXCIV.

551.79
K33

250049

ON THE GLACIAL GEOLOGY OF THE ISLE OF MAN:

By PERCY F. KENDALL, F.G.S., Lecturer on Geology at the Yorkshire College, Leeds.

CONTENTS.—I. Introductory; II. Bibliography; III. Physical Geography and Geology; IV. Transport of Local Stones; V. "Aspect of the Crags"; VI. Surface-features of the Drift-deposits; VII. The Glacial Striæ; VIII. The Origin of the Foreign Boulders; IX. The Drift Deposits; X. Palæontology; XI. Theories; XII. Post-Glacial History; XIII. Summary.

I.—INTRODUCTORY.

The following paper was written so long ago as January, 1891, and the substance of it was communicated to a meeting of the Isle of Man Natural History and Antiquarian Society, held at Chester on 31st July, 1891, but, owing to later investigations rendering some revision necessary, I have been permitted to re-cast the whole paper, so as to make it as full a compendium of the subject as the space allotted to me will admit. To the same end I have added an approximately complete bibliography, omitting intentionally only such papers as merely quote with approval the other sources of information. The broader theoretical views which here find expression are not adopted to meet this one special case, but are part of a general scheme which embraces the whole of the British Isles, and for which I claim no originality. It first found clear expression in that remarkable paper by Mr. Goodchild (Q.J.G.S., vol. xxx., 1874). It was adopted promptly and supported with great ingenuity by the late Thomas Belt, the late Dr. Croll, by Professor James Geikie apparently, and, more recently, by the late Professor H. Carvill Lewis. The latest statement of the theory is that which, at the request of my friend, Professor G. F. Wright, LL.D., I contributed to his book, "Man and the Glacial Period" (1892), and to this I must refer any readers to whom a more general statement would be helpful.

The glacial phenomena of the Isle of Man are of exceptional interest, by reason of the unrivalled excellence of the sections wherein they are displayed, and their extraordinarily diversified character. Not only may we see illustrations of almost every kind and modifications of glacial deposit which can be observed elsewhere, together with surface features such as drumlins, swamp hollows, and *roches moutonnées*, but there are special features which have as yet been observed nowhere else. When it is added that there is a fauna entombed in the Manx drift which includes types to be found in no other deposits, it needs no argument to prove that, interesting as are some of the older formations in the Island, the glacials yield the palm to none.

II.—BIBLIOGRAPHY.

Strickland, H. S., Proc. Geol. Soc., vol. iv., p. 8, 1843.
Cumming, Rev. J., Q.J.G.S., vol. ii., p. 317, 1846.
Cumming, Rev. J., Q.J.G.S., vol. ii., p. 335, 1846.
Cumming, Rev. J., Q.J.G.S., vol. iii., p. 179, 1847.
Cumming, Rev. J., "The Isle of Man," 1848 (Van Voorst, London).
Cumming, Rev. J., Guide to the Isle of Man, 1861 (Stanford, London).
Horne, J., Trans. Edinb. Geol. Soc., vol. ii., part iii., 1874.
Grindley, T., Brown's Popular Guide to the Isle of Man (Jas. Brown & Son Douglas).
Forbes, E., Mem. Geol. Surv. of Gt. Britain., 1846, vol. i, p. 336 *et seq.*
Forbes, E., Brit. Assoc. Report., 1840.
Forbes, E., Malacologia Monensis, 1838.
Ward, J. Clifton, Geol. Mag., 1880, p. 1.
Birds, J. A., Geol. Mag., 1875, pp. 80, 226, 329, 425.
Howorth, H. H., Geol. Mag., 1877, p. 410.
Morton, G. H., Geol. Mag., 1879, p. 211.
Hewitt, W., Proc. L'pool Geol. Soc., 1887-8.
Kermode, P. M. C., Yn Lioar Manninagh, vol. i., No. 4, p. 96.
Haviland, A., Yn Lioar Manninagh, vol. i., Nos. 4 and 5, p. 57.
Tellet, F. S., Trans. Manx Geol. Soc., 1889-90.
Harrison, Rev. S. N , Yn Lioar Manninagh, vol. i., No. 8, 1891.
Harrison, Rev. S. N., Brit. Assoc. Report, 1891, p. 297.
Harrison, Rev. S. N., Trans. Isle of Man Nat. Hist. Soc., 1892-3.
Kendall, P. F., Proc. Manx Geol. Soc., 1889.
Kendall, P. F., Brit. Assoc., Report, 1890, p. 807
Kendall, P. F., Proc. Manch. Lit. and Phil. Soc., Feb., 1891.
Kendall, P. F., *Manchester Examiner* Newspaper, Aug., 1891.
Kendall, P. F., Man and the Glacial Period (Internatl. Scient. Series), 1892 p. 137 (2nd ed., 1894.

Other papers referred to in the following pages:—

Tiddeman, R. H., Q.J.G.S., vol. xxviii. p. 487, 1872.
Lomas, J., A.R.C.S., Brit. Assoc. Report, 1892, p. 707.
Cole, Prof. G. A. J., F.G.S., Nature, vol. xlvii., p. 464.
Lamplugh, G. W., F.G.S., Proc. Yorks Geol. Soc., vol. ix., part i., p. 57
Shone, W., F.G.S., Q.J.G.S., vol. xxxv., p. 383.
Praeger, L., Irish Naturalist, vol. iii., No. i., p. 18.

III.—PHYSICAL GEOGRAPHY AND GEOLOGY.

The general outline of the Island may be described as somewhat like the deck of a ship. The prow would be directed to the N.E., and the blunt stern to the S.W.

The relief of the country is bold, and there is a hilly axis which roughly coincides in trend with the length of the Island. A narrow midland valley, nowhere rising above 150 feet O.D., stretches completely across from Douglas to Peel. Another low valley extends from Port St. Mary to Port Erin.

The Northern half of the Island consists of a great quadrilateral *massif*, or hill-plexus, which extends almost to the coast on the East and West, while to the northward it terminates in a line extending from Ramsey to the neighbourhood of Kirk Michael in a series of declivities so steep as to suggest the idea of an old line of sea cliffs. The slopes are often 40° and upward, and in few places are roads made directly up the faces, but advantage is taken of the deep glens which penetrate among the hills. The southward termination, towards the midland valley, is, in general, much less abrupt, though, at about the centre of the line, Greeba descends precipitously.

To the northward of the Ramsey and Kirk Michael line, the country consists of a low tract of land of a triangular form consisting entirely of drift deposits, probably down to below sea-level. A line of hills—the Bride Hills—culminating at Shellag in an eminence 270 feet high, extends almost from sea to sea in a sweep, having the convexity north-westward, and enclosed between these hills and the central massif is a very low-lying area with occasional small mounds. the whole drainage of which is very imperfect, so that in former times considerable lakelets existed which have been drained recently, but there are still considerable tracts of swamp which have not yet yielded to the draining operations.

In the Southern half of the Island, the hills are more scattered; but lines of elevated land. which originate on the South side of the central valley, converge upon Cronk-na-Irrey Lhaa, and sub-parallel ridges flank the main lines on either hand.

The Solid Geology is mainly composed of greatly folded and contorted Skiddaw Slate with a dominant N.E. and S.W. strike, agreeing with the direction of the long axis of the Island. The slates rarely show any approach to cleavage. They are generally soft, and fissile, and contain many interstratified beds of grit.

In the South of the Island a basin of Carboniferous Limestone occurs, making a natural outcrop on the North from the coast at Cass-ny-Awin to Athol Bridge, and cut off upon the West by a fault extending from Athol Bridge through Port St. Mary to the sea.

Another strip of Carboniferous Limestone formerly existed near Peel, but, according to Cumming, it has been entirely removed by quarrying; there, however, still survives at Peel and along the coast to northward a considerable patch of a red sandstone and conglomerate, which has been regarded as the equivalent of sandy and conglomeratic beds beneath the limestone in the Southern basin.

Many well-characterised Igneous rocks of the highest value to the glacialist occur in various parts of the Island. In a quarry above Ballure, near Ramsey, is found a handsome quartz-diabase,* with iron pyrites and

vermicular chlorite. At Dhoon a great intrusive boss of granite occurs, of a greyish tint, with a strongly-marked sheared aspect. It contains a brown mica, disposed in a gneissose arrangement. Round about this mass very well-marked contact-metamorphism has taken place, and the curiously altered rocks are traceable with tolerable certainty in the Manx drift.

---

* I have made no special study of these Igneous rocks, and give such names as a rather superficial examination suggests.

On precisely the same parallel near the west coast a very handsome compact blue-grey quartzite crops out at a place called "The Carrick," on Skerestal-Mooar farm. Further south, at Rockmount, Poortown, between St. John's and Peel, a splendid dark green rock, with very large Augite crystals, is exposed in quarries. It has been called by the late Prof. Carvill Lewis a Pikrite. Near Crosby another Igneous outcrop occurs—a quartz-porphyry, I believe.

The next Igneous rock to put in an appearance in the southerly direction, is the well-known granite of Foxdale. It is a huge boss cropping out all over "Granite Mountain" (657 feet above O.D.); and it is met with in the lower levels of the Foxdale Mine. The rock is easy of recognition, being quite unlike any other granite in the Irish Sea basin. It is a white granite, without any one constituent standing out in especial prominence, and—which distinguishes it from most of the granites of Galloway—the felspars are not well formed. The mica is silvery white to pale-brown in colour.

Another small patch of granite has recently been discovered in Santon Glen. It is white, and of a fine texture; but not sufficiently well characterised to be readily, if at all, distinguished from some varities of the Creetown granite.

In the Langness Peninsula, and near Balladoole (Bay-ny-Carricky), dykes of, apparently, Pre-Carboniferous age penetrate the Skiddaw slates; and at the former locality masses of "greenstone" also are found. For a description of the latter and of the marvellous series of volcanic rocks at Scarlett Point, I must refer readers to the paper by Mr. Bernard Hobson, M.Sc., F.G.S.*

It will be seen from the foregoing rough outline of Manx geology, that there is no lack of those igneous rocks of which the glacialist makes so much use in the study of boulder-transport; and if, in the ensuing pages I am compelled to be silent regarding the distribution as erratics of some of them, it must be understood that it is from absolute default of evidence.

IV.—TRANSPORT OF LOCAL STONES.

The enumeration of the well-characterised igneous rocks mentioned in the last section would arouse in the minds of many glacialists the expectation that critical facts would be brought to light when the distribution of their fragments as boulders came to be studied, facts fraught with the issues of life and death to the great theories of glaciation which are at present before the world. We are, unfortunately, at present but ill-informed upon the subject, though, happily, there are able workers in the field to whom it may be that these lines may prove helpful; but enough has been—nay had been nearly 50 years ago—done, to place in the hands of geologists one of the most potent arguments furnished by the whole range of knowledge on the subject.

Regarding boulders of the rocks of *Ballure*, *Skerestal*, and *Poortown*, nothing positive is known, but I have very carefully searched the country to the northward of the outcrops, and have never found a fragment of any of them.

The Carboniferous Rocks of the Peel Outcrop.—I have found the sandstones in a section at Peel, (corner of Church-street), at the reservoir

of the Peel Waterworks, and at several places on the way up Slieu Whallian. It will be observed that all these places are to the south of the natural outcrop. An apparent exception is the case, to be described in the sequel, of multitudes of red sandstone and Carboniferous Limestone boulders at Jurby, but Cumming ascribed them, as I should do, to some adjacent submarine outcrop.

---

* Q.J.G.S., Vol. xlvii., p. 432; and "Yn Lioar Manninagh," 1892, p. 337.

The Dhoon Granite is, as I have remarked, a very boldly marked rock very easy of recognition, and I have taken especial pains to trace out, so far as my limited opportunities would permit, the extent of its outcrop and the distribution of boulders from it. The outcrop extends over the moorland known as "The Barony," across to Glen Callan and Dhoon Glen, thence across the Douglas-road, and it is said that an apophysis runs over to Slieu Rûy. So far as I can learn, no boulder of this rock has ever been seen to the northward of the point at which a bye-road from the northward falls obliquely into the Douglas-road just south of Ballelin.* From this point, they are scattered in profusion to, and past, Laxey. Off the main road, I have found decomposed blocks of what I took to be this rock, at Agneish, and at North Baldrine, on the opposite side of Laxey Glen. Quite at the head of the Glen, on the flanks of Snaefell, I found also a rock much resembling that of the "Contact Zone" of the Dhoon Granite. My traverses of this dispersion, were, besides journeys along the line and to the northward, a walk up the valley from Corrany to the higher lead mines, then over the col between Slieu Lhean and Slieu Ruy, down to Agneish and Laxey, and again from Laxey via Cronk-y-Vaare to Snaefell, and along North Barrule to Ramsey. It will be observed that no boulders were carried from the Dhoon mass northward, but that multitudes went southward, and some, perhaps, were carried a little to the south-west of the outcrop. I have found one or two boulders of this rock at "The Chasms," near Spanish Head, in the extreme south.

Regarding the *Crosby* rock I have nothing to say.

The Foxdale Granite.—The distribution of boulders of this rock has been studied very carefully by Cumming, and his observations have been frequently quoted by writers as illustrations of the action of land-ice.† The granite crops out in a compact boss, forming the hill called "Granite Mountain," which, I am informed, by the Director of the Ordnance Survey, is 657 feet above O.D. The extensive mine working in the neighbourhood renders it in a high degree improbable that there is any other outcrop which has escaped notice, and Cumming said that he had searched unavailingly for signs of such an outcrop (which, by the way, would have relieved him, as he confessed, of a considerable difficulty), and had "inquired for it in vain amongst the miners in that neighbourhood."

Cumming showed that the boulders had been carried in great numbers in a general southerly direction, but my own observations indicate that the main dispersion was to the south-west. From this general direction there were considerable deviations. Cumming notes examples on Langness, the Brough, near Ballasalla, and at Arragon Beg (Santon), which appears to be the most easterly point reached, and says it bears S.E. from the granitic boss, but the bearing is in fact only a few degrees--10° at most—east of south. From here they sweep in increasing numbers round to Port Erin, where they are very abundant, and on via Fleshwick Bay to—according to Cumming—Dalby Head. This last point is rather doubtful, for the author

vermicular chlorite. At Dhoon a great intrusive boss of granite occurs, of a greyish tint, with a strongly-marked sheared aspect. It contains a brown mica, disposed in a gneissose arrangement. Round about this mass very well-marked contact-metamorphism has taken place, and the curiously altered rocks are traceable with tolerable certainty in the Manx drift.

---

* The points mentioned are marked on the one inch Ordnance Maps.

† Horne, Trans. Geol. Soc. of Edin., Vol. II., Part III. Tiddeman, Q.J.G.S Vol. xxviii., p. 487.

On precisely the same parallel near the west coast a very handsome compact blue-grey quartzite crops out at a place called "The Carrick," on Skerestal-Mooar farm. Further south, at Rockmount, Poortown, between St. John's and Peel, a splendid dark green rock, with very large Augite crystals, is exposed in quarries. It has been called by the late Prof. Carvill Lewis a Pikrite. Near Crosby another Igneous outcrop occurs—a quartz-porphyry, I believe.

The next Igneous rock to put in an appearance in the southerly direction, is the well-known granite of Foxdale. It is a huge boss cropping out all over "Granite Mountain" (657 feet above O.D.); and it is met with in the lower levels of the Foxdale Mine. The rock is easy of recognition, being quite unlike any other granite in the Irish Sea basin. It is a white granite, without any one constituent standing out in especial prominence, and—which distinguishes it from most of the granites of Galloway—the felspars are not well formed. The mica is silvery white to pale-brown in colour.

Another small patch of granite has recently been discovered in Santon Glen. It is white, and of a fine texture; but not sufficiently well characterised to be readily, if at all, distinguished from some varities of the Creetown granite.

In the Langness Peninsula, and near Balladoole (Bay-ny-Carricky), dykes of, apparently, Pre-Carboniferous age penetrate the Skiddaw slates; and at the former localitv masses of "greenstone" also are found. For a description of the latter and of the marvellous series of volcanic rocks at Scarlett Point, I must refer readers to the paper by Mr. Bernard Hobson, M.Sc., F.G.S.*

It will be seen from the foregoing rough outline of Manx geology, that there is no lack of those igneous rocks of which the glacialist makes so much use in the study of boulder-transport; and if, in the ensuing pages I am compelled to be silent regarding the distribution as erratics of some of them, it must be understood that it is from absolute default of evidence.

IV.—TRANSPORT OF LOCAL STONES.

The enumeration of the well-characterised igneous rocks mentioned in the last section would arouse in the minds of many glacialists the expectation that critical facts would be brought to light when the distribution of their fragments as boulders came to be studied, facts fraught with the issues of life and death to the great theories of glaciation which are at present before the world. We are, unfortunately, at present but ill-informed upon the subject, though, happily, there are able workers in the field to whom it may be that these lines may prove helpful; but enough has been—nay had been nearly 50 years ago—done, to place in the hands of geologists one of the most potent arguments furnished by the whole range of knowledge on the subject.

Regarding boulders of the rocks of *Ballure*, *Skerestal*, and *Poortown*, nothing positive is known, but I have very carefully searched the country to the northward of the outcrops, and have never found a fragment of any of them.

The Carboniferous Rocks of the Peel Outcrop.—I have found the sandstones in a section at Peel, (corner of Church-street), at the reservoir

of the Peel Waterworks, and at several places on the way up Slieu Whallian. It will be observed that all these places are to the south of the natural outcrop. An apparent exception is the case, to be described in the sequel, of multitudes of red sandstone and Carboniferous Limestone boulders at Jurby, but Cumming ascribed them, as I should do, to some adjacent submarine outcrop.

---

* Q.J.G.S., Vol. xlvii., p. 432; and "Yn Lioar Manninagh," 1892, p. 337.

The Dhoon Granite is, as I have remarked, a very boldly marked rock very easy of recognition, and I have taken especial pains to trace out, so far as my limited opportunities would permit, the extent of its outcrop and the distribution of boulders from it. The outcrop extends over the moorland known as "The Barony," across to Glen Callan and Dhoon Glen, thence across the Douglas-road, and it is said that an apophysis runs over to Slieu Rũy. So far as I can learn, no boulder of this rock has ever been seen to the northward of the point at which a bye-road from the northward falls obliquely into the Douglas-road just south of Ballelin.* From this point, they are scattered in profusion to, and past, Laxey. Off the main road, I have found decomposed blocks of what I took to be this rock, at Agneish, and at North Baldrine, on the opposite side of Laxey Glen. Quite at the head of the Glen, on the flanks of Snaefell, I found also a rock much resembling that of the "Contact Zone" of the Dhoon Granite. My traverses of this dispersion, were, besides journeys along the line and to the northward, a walk up the valley from Corrany to the higher lead mines, then over the col between Slieu Lhean and Slieu Ruy, down to Agneish and Laxey, and again from Laxey via Cronk-y-Vaare to Snaefell, and along North Barrule to Ramsey. It will be observed that no boulders were carried from the Dhoon mass northward, but that multitudes went southward, and some, perhaps, were carried a little to the south-west of the outcrop. I have found one or two boulders of this rock at "The Chasms," near Spanish Head, in the extreme south.

Regarding the *Crosby* rock I have nothing to say.

The Foxdale Granite.—The distribution of boulders of this rock has been studied very carefully by Cumming, and his observations have been frequently quoted by writers as illustrations of the action of land-ice.† The granite crops out in a compact boss, forming the hill called "Granite Mountain," which, I am informed, by the Director of the Ordnance Survey, is 657 feet above O.D. The extensive mine working in the neighbourhood renders it in a high degree improbable that there is any other outcrop which has escaped notice, and Cumming said that he had searched unavailingly for signs of such an outcrop (which, by the way, would have relieved him, as he confessed, of a considerable difficulty), and had "inquired for it in vain amongst the miners in that neighbourhood."

Cumming showed that the boulders had been carried in great numbers in a general southerly direction, but my own observations indicate that the main dispersion was to the south-west. From this general direction there were considerable deviations. Cumming notes examples on Langness, the Brough, near Ballasalla, and at Arragon Beg (Santon), which appears to be the most easterly point reached, and says it bears S.E. from the granitic boss, but the bearing is in fact only a few degrees--10° at most—east of south. From here they sweep in increasing numbers round to Port Erin, where they are very abundant, and on via Fleshwick Bay to—according to Cumming—Dalby Head. This last point is rather doubtful, for the author

apparently speaks of it as "on the western slope of Irey-na-Laa," from which it is distant about 3½ miles; and it would almost seem that Cumming had written "Dalby Head" for "Stroin Vuigh," which is on the western slope of "Irey-na-Laa." Be this as it may, the main dispersion has been to the south-west, with a very few straggling to a few degrees east of south, and a few points north of west. I have carefully searched, but have never met with a single fragment of the granite to the northward of the outcrop. The relation of the boulders to the hilly axis is the most remarkable feature of the dispersion. Cumming says that they occur plentifully on Cronk-na-Irey-Lhaa, even on its very summit, 1,449 feet above O.D., and 792 feet above their parent mass; but, more significant still, he saw "one large boulder, weighing apparently more than two tons, on the western side of South Barrule, within a hundred feet of the summit," and I have seen a very large boulder at just about the same altitude on the north-western face. The uplift here has been 828 feet in a distance of two miles!

---

* The points mentioned are marked on the one inch Ordnance Maps.

† Horne, Trans. Geol. Soc. of Edin., Vol. II., Part III. Tiddeman, Q.J.G.S Vol. xxviii., p. 487.

The Carboniferous and Igneous Rocks of the South.—No definite dispersion of these has been clearly made out, but the following points have been noted:—In a section of till at Hango Hill, near King William's College, multitudes of cuboidal blocks of Carboniferous Limestone occur, which, though well scratched, have evidently not travelled far. Cumming says: "They have all the appearance of having come from Skillicore, near Coshnahawin, a mile and a half to the north-eastward." Again, after describing the striated surfaces at Scarlet and Poyll Vaaish, he proceeds:* "Now, had the drifting current come from the W.S.W., it would almost necessarily have carried along with it, in passing over Scarlet Head, some of the trap-tuff and fragments of the Posidonia schist; but at the before-mentioned locality, near the Stack, where the scratchings and the boulder-clay are well seen, and which is only a few hundred feet to the eastward of the trap-tuff, I have not yet found a single fragment of this rock. . . . The same conviction as to the direction of the drift arises from an examination of the colour of the boulder-clay where it is in contact with the subjacent rock. In Poolvash Bay, to the westward of the trap-tuff, it is of a yellowish brown colour, and very ochreous. Near the Stack of Scarlet it is a dark blue, having obtained its materials from the dark limestones and shales of Castletown Bay. Further to the westward, we find it on the Brough of a reddish brown tint, which it seems to have derived from the beating of denuding waves upon the escarpment of the old red conglomerate above Cosnahawin Head. At Port-le-Murray again, near the limekilns, it is of a dingy dark blue colour, possibly obtained from the older dark limestones of Poolvash Bay." In his guide book, the same author mentions the occurrence of trails of boulders proceeding in a south-westerly direction from the igneous intrusions on Langness.

These conclusions are confirmed in the main by my experience; but I ought to mention that on Bradda Head I found a rock much resembling the agglomerates of Scarlet Point; and on Spanish Head (Spalorck) a block of a stone, which may be identical with Cumming's "greenstone" intrusions, near St. Michael's Island. These, if authentic determinations, would imply a movement almost from E. to W., like that of the Foxdale granite to Dalby Head There are no indications of a considerable movement in the direction named.

V.—THE "ASPECT OF THE CRAGS."

The Aspect of the Crags.—Though records of ice-action on the high grounds are few and scanty, yet Cumming noted, nearly fifty years ago, the fact that the whole Island when viewed from a boat presented a *moutonnée* appearance. Mr. Horne, whose wide experience invests his utterances with a special weight, endorsed Cumming's remarks, and said that the circumstance could not fail to strike an experienced glacialist. The *moutonnée* condition of the hills can be readily discerned by noting the general smoothness of the *North-easterly* slopes and the rough condition of the *South-western* sides of the hills. Greeba offers the most striking illustration of this in the whole Island, but it is also very noticeable in crossing the col joining Slieu Lhean to Slieu Ouyr. As the col is approached from the North, from the lead-mines above Corrany, there is not a bit of live-rock to be seen ; but, no sooner is the ridge surmounted, than jutting crags crop out giving a boldness in striking contrast to the smooth, almost monotonous features previously encountered. South Barrule displays similar though less strongly marked characteristics. It is well to remark that in a few cases, such as Lhergy Frissell and Cronk-ny-Vaare (a spur of the Mullagh Ouyr) the roughest side is towards the North ; but in the former case, certainly, and probably in the latter also, the great steepness of the northerly slope has, I think, operated to prevent ice-rasping. (See *post.* on the splitting of the ice at Frissell).

---

* Q.J.G.S. 1846, p. 338-9.

VI.—SURFACE FEATURES OF THE DRIFT DEPOSITS.

The surface features of glacial deposits often furnish valuable indications regarding the agencies which have been concerned in their accumulation. Thus, the long steep-sided ridges of boulder-clay, called "drumlins," which are found in many glaciated regions have been found to be the work of land-ice, moving in the direction of their length. Again, eskers are similarly disposed to the ice-movement, but consist of long gravel ridges. Terminal moraines, when related to small valley-glaciers, generally consist of more or less clearly-defined crescentic mounds, the convex front looking down the valleys ; but when the moraine has been laid down at the front of a very large glacier, or ice-sheet, it is often much more irregular, usually consists of a plexus of hills, and very commonly—*invariably*, in my experience—encloses among its reticulations swamp-hollows, or hollows without any outlet for drainage. Moraines of this class are so similar to many large eskers that I am quite unable to discover any certain means of diagnosis. The moraines will, of course, be transverse to the ice-flow, instead of parallel to it, as in the case of eskers ; but, as I shall presently explain, the finest development of hills of this character in the Isle of Man are in a region where the direction of flow underwent a peculiar modification, of unknown extent.

Cumming's description* and my own observation show that a considerable number of the hills in the neighbourhood of Colby and Ballasalla are composed of boulder-clay, and have the form characteristic of drumlins—*e.g.*, the "rounded hill to the north-east of Ballahot, Skybright and the Brough."

Esker mounds are also very abundant in the same district, and they and the drumlins all exhibit a remarkable parallelism of their long axes. Cumming says, "All the hills in this neighbourhood have greatly the character of the Scandinavian trainées, or osar [esker], the long axis running from N.E. by E."

I may here remark that, where possible, I prefer to quote Cumming, as he had no special theory to support ; and, therefore, there could have been no bias in his mind to distort his judgment. It is well to observe the agreement between the direction of ice-movement indicated by these phenomena and that deducible from the transport of boulders and drift material and the striæ upon rock surfaces.

---

* Q.J.G.S., 1846, p. 33, and "Isle of Man.'

In other parts of the Island similar facts may be brought to light by a systematic survey, but I can speak only for the Sheading of Ayre. The great range of drift-hills which extends from Shellag Point, via Kirk Bride, and in a great sweep down to Ballaugh, presents features characteristic of hills of deposition as distinguished from hills of denudation. In the Bride Hills these characters are very well displayed ; the hills have a billowy appearance, very steep sides, they often enclose hollows without drainage outlets, and the bedding of the sand and gravel of which they are composed may be seen to be parallel to the slope of the hill sides. Whether these are portions of a great moraine, or whether constituting an esker, I cannot decide. In the town of Ramsey, along the back of Waterloo-road, is a long ridge of sand and gravel, displaying in some sections very markedly the phenomenon of bedding parallel to the surface, and I think it may be proved to be an esker. The long axis runs about N.W.-S.E., a direction which conforms very nearly with that which I should on theoretical grounds assign to the ice-movement in the neighbourhood.

VII.—THE GLACIAL STRIÆ.

The character of the rocks which constitute the major portion of the solid geology of the Isle of Man is very unfavourable to the preservation of glacial scratches, being a rugged and fissile slate, striking approximately in what I regard as the line of ice-flow. In the south of the Island, however, a considerable area is occupied by Carboniferous Limestone, and here, as Mr Hewitt remarks,* "whenever the junction of the Till with the underlying limestone is seen, the latter is found to be polished and well striated." The opportunities for observation are limited, but the following have been recorded :—

Scarlet Limekilns.—W. 27° S., to S. 28° W.—The direction of movement is, Mr Hewitt points out, indicated by small *moutonnées* knobs, which have their weather sides to the N.E. Clifton Ward supposed that these scratches were caused by floating ice, but the opinion of Mr Horne is decidedly in favour of an ice-sheet having produced them, and that view is also expressed by Mr Hewitt.

At Poyll vaaish, the direction is W. 40° S.

At Port St. Mary Breakwater they range from W. 32° S. to S. 28°--32° W.

In a quarry on the shore at *Port St. Mary*, they run W. 34° S. and S. 35°—37° W. The remarks of Mr. Hewitt upon these are of very great importance. He describes the stepped appearance of the horizontally bedded limestone, and says : "At the breakwater at Port St. Mary, the till abuts against an almost vertical stepped cliff of this kind. The bed of limestone on which the till rests, and which is capped by four or five higher beds in the cliff is finely polished and striated down to a line running from the inland edge of the cliff in the general line of the striæ towards the sea. Again, at the lime-kilns at Port St. Mary, the upper limestone beds end inland in a succession of six steps, against which abuts a mass of unstratified stony till. Each step is well polished and striated on both its horizontal and its exposed vertical sides ; the horizontal edges are well rounded off and the striæ may be seen running obliquely from the horizontal to the vertical faces."

"It seems to me plain that this kind of action could only be caused by a sheet of land-ice which moulded itself exactly to the existing contour of the rock."

My own observations supplement those of Mr. Hewitt in one significant particular : striæ occur on the *under side* of overhanging ledges, and along the sides of narrow tortuous joints, to a depth of one to one and a half inches. This phenomenon I also observed at the Scarlet Quarries.

---

* Proc. Liverpool Geol. Soc., 1887-88.

The features displayed by these striæ, taken with their constancy of direction, and the fact that they run parallel to the hilly axis, point irresistibly to the conclusion that they were the product neither of floating ice nor of local glaciers; and the opinion of Mr. Horne is fully sustained that "it is hardly necessary to point out that these markings cannot be accounted for by any mere local glaciation. . . . We can only account for the phenomena by inferring that the Isle of Man was glaciated by ice from the mainland."

The only other indications of the direct action of ice are the crushed and shattered condition of the edges of the clay slate rocks seen in some sections. Mr. Hewitt mentions an example of this kind at Port Erin, which may be fairly described as "terminal curvature," for the bending was opposed to the slope of the ground, and states that, so far as he could ascertain, the bending was towards the south-east. This case is of importance, as the direction is athwart that indicated. I have carefully searched this section, and have been unable to discern the features described, whence I should infer that the phenomenon was on a small scale, and had, in the interval between our visits, been removed by denudation; however, such as it is (and Mr. Hewitt, with characteristic caution, qualifies his record with "as far as I could ascertain"), the evidence points to a movement nearly at right angles to the normal direction.

I can now record the discovery by myself and Mr. P. M. C. Kermode of a small striated surface on the S. side of South Barrule, at an altitude of probably 1,300 feet. It is about 30 yards to the westward of Crag-ny-Vaare, and the striæ run towards about S. 4° or 5° E. The Rev. S. N. Harrison has also found striæ on Maughold and above Claghbane, Ramsey; and to these I must refer later. Mr. Clifton Ward has seen striæ on the Skiddaw slate at Port Groudale, running "nearly north and south."

VIII.——THE ORIGIN OF THE FOREIGN BOULDERS.

The foreign boulders of the Manx drift are of very varied character, and, though the source or origin of many of them may never be discovered, a fair acquaintance with the igneous rocks of the Lake District and the mountainous region of the south-west of Scotland (Wigtonshire and Kirkcudbrightshire) enables me to say that the vast majority of the erratics come from those two regions. The Lake District is represented by a very small number of examples of the granite of the Eskdale mass, by rather more numerous examples of the Buttermere Granophyre, and the Rev. S. N. Harrison informs me that he found two small blocks of Shap granite at the Dog Mills. Far more numerous than the Lake District rocks are those derived from the S.W. of Scotland. In that wild and beautiful country large areas are occupied by outcrops of granite, and speaking from a pretty extended experience of the granites of England, Scotland, and the Western Isles, I can say that nowhere, so far as I am aware, is there so great a range of variation in aspect or structure to be found in a whole outcrop covering many square miles as is often to be met with in a single quarry in Kircudbrightshire. Thus, one may find a normal grey granite assuming a bright red colour (this is almost constantly observable in this region in the neighbourhood of joints); the grain varies in an extreme degree, and one mineral constituent may attain very large dimensions, while the main mass may be composed of mineral particles of much less than the normal dimensions. Again, within two or three yards one or other of the constituent minerals may disappear wholly, and perhaps an accessory mineral not present in the body of the rock may be developed. These features are nowhere better displayed than in the Burnfoot quarry, near Kenmuir Castle, Loch Ken.

Now, with the knowledge that the rocks are thus variable, it behoves me to speak with diffidence of any precise identification of the source of boulders even though resemblances may be very striking; still it would appear that there are constant features of the main masses by which they may perhaps be recognised. The granites of Creetown are generally fine-grained, and of a grey colour, and with the felspar particles *sub-equal;* the granites of Cairnsmore of Fleet, and Cairnsmore of Dee, are usually of a more milky-white, often tinged with red, and with felspars of two stages of crystallisation, the older being a quarter to half an inch in length and fairly well formed, while the newer are little more than granules intermingled with the quartz of the ground-mass. The Loch Doone granite I have seen only in museums, and the specimens appeared to be fine-grained, of a deep red colour, and with a profusion of black mica. Round about Dalbeattie, all the granites which I saw from the numerous quarries were characterised by the occurrence of porphyritic crystals of felspar, of a pink, or almost lilac, hue, embedded in a grey ground. This character appears distinctive. In the Manx drift, granites from each of the masses named can be found, but, so far as my observations went, I should say that the great majority of the granite erratics came from Creetown and the Cairnsmores.

Vast quantities of large granite boulders are to be seen built into walls and hedges in the neighbourhood of Kirk Bride, and the Church at that place, which is built largely of them, presents an admirable opportunity for the determination of the relative abundance of the different kinds.

The Silurian series of Wigtonshire includes a number of grits and sandstones, for the most part of a grey colour, which are tolerably easy of recognition, and especially a coarse grit containing large fragments of quartz and of black slatey rock This grit I have found *in situ* near Newton Stewart (precisely on the same meridian as Sulby), and as erratics at many places in the Isle of Man, but particularly on the hill between Port Lewaigue and Maughold. The great " Bautr-stone," at East Kimmeragh, on the Bride Hills * is, I believe, composed of this grit.

Ireland appears to have yielded few boulders to the Manx drift, and it may even be questioned whether it has yielded any. The only rocks to which an Irish origin may, with any degree of probability, be assigned are some rather numerous fragments of a drusy granite, which I have found in Port Erin Bay, and the flints which are so abundant in the low-level drift of the North of the Island, and less so in the equivalent deposits of the South. Regarding the granite :—It is a yellowish-grey rock of fine grain with drusy cavities, about one inch apart, into which project the ends of small crystals of quarts, felspar (*albite*, I believe), and a greenish mica. This may be a variety of the well-known drusy granite of the Mourne Mountains, a supposition rendered the more probable by the fact that the boulders have been found only on the west side of the Island ; but, as I have only seen *selected* museum specimens of the Mourne Mountain granite, in which drusy structures were much better developed than in my Manx boulders, I cannot say that the resemblance between them amounted to identity. Flints offer a problem that I confess my inability to solve. It is usual to ascribe all the flints in the drift of the countries bordering the Irish Sea to an origin in the Antrim Chalk, and to suppose that the agency which carried the other drift materials brought them directly from the parent mass ; but I have ventured to express the belief, which I have long entertained, that, even if the derivation of these flints *directly* from the Chalk could be proved, it would still be open to discussion whether they had not been derived from some, at present submerged, outcrop of the Chalk. The cretaceous rocks of Antrim come right down to the coast, and it can hardly be doubted that they extend a considerable distance under the sea. But the condition of these flints very strongly opposes the idea of *direct* derivation. In the eastern counties of England certain divisions of the drift contain multitudes of chalk-flints which, albeit occasionally showing rubbed and glaciated faces, are in general as fresh and unworn as flints fresh from the quarry would be. Now, in the Manx drifts, I have never met with a single example which retained either the irregular form or the soft white coat of the fresh flint. Some are well-rounded, and bear all the appearance of beach-pebbles, while a not inconsiderable proportion are sub-angular, and were, I should say, derived from river-gravels. Both kinds rarely attain the size of a man's fist. The conclusion which I should be disposed to draw from the evidence is that all the flints had been derived from sea-beaches or river-terraces which had lain in the path of the ice by which the Isle of Man was glaciated. I may remark that some geologists are of opinion that a patch of chalk occupies a portion of the bed of the Solway Frith, or the immediately adjacent portion of the Irish Sea, but some of the Manx flints have the red colour which those of Antrim have acquired by proximity to the igneous rocks of that district.

---

* *Yn Lioar Manninagh*, Proceedings and Transactions, vol. i., part 2, pp. 181 and 184.

There now remains to be mentioned two remarkable erratics which are the only examples as yet recorded of rocks foreign to the Irish Sea basin. The first entry in my note-book relating to Manx geology is a description of the Ballure section, and it makes mention of "*a pale green rock with violet spots (like vivianite), which is common in all the glacials about Ramsey.*" This rock I found subsequently in all the Manx low-level drifts, and its origin remained a mystery until, upon the discovery of fragments on Moel Tryfaen, North Wales, I sent specimens to petrologists in Dublin, Edinburgh, and London, in the hope that someone would be able to identify it. My Dublin correspondent was the first to reply, and he pronounced it to be unlike any Irish rock with which he was acquainted; but suggested that, as the blue mineral (which I had already identified with a rare Hornblende) was known from only one locality in the British Isles, viz.:—Mynydd Mawr, a hill which actually joins Moel Tryfaen, the rock, though very unlike the specimens hitherto examined from Mynydd Mawr, might still be from an unexplored portion of the same mass. To this view I urged the objection that its occurrence in abundance in the Isle of Man pointed, in accordance with the observed direction of transport of erratics in the basin of the Irish Sea, to derivation from some source to the northward of the Island. A few days later, Mr. J. G. Goodchild wrote from Edinburgh to say that the officers of the Scottish Geological Survey had positively identified the rock as the Eurite (or Granophyre) of Ailsa Craig, in the Firth of Clyde.* Details of its distribution in the drift of England and Wales are given in a paper by Mr. J. Lomas, A.R.C.S.(†); and Prof. G. A. J. Cole has found it in Ireland.‡ The Manx erratics of this rock rarely attain a length of more than six inches.§ The occurrence of boulders from the Firth of Clyde is one of the apparent anomalies of the Manx Glacial phenomena, but a reference to Mr. Horne's masterly paper quoted at the outset shows that not only is the case provided for in his review of causes of the glaciation of the Isle of Man, but it furnishes very strong corroboration of the other evidence upon which he relied. He pointed out that the striæ upon rock surfaces down the coast of Ayrshire and over the Mull of Galloway show that a portion of the great stream of ice coming down from the Highlands swept down the Firth of Clyde, and in part entered the Irish Sea.

---

* Proc. Manch. Lit. and Phil. Soc., 1891.

† Brit. Assoc. Rep., 1892, p. 707. ‡ "Nature," vol. xlvii., p. 464.

§ I have entered into some detail here as the prediction was based upon the general theory of glaciation set forth in the sequel, and its verification lends additional support to that theory.

A second rock from the Clyde has been obtained by Mr. Harrison on the shore at Port-e-Mwyllin, Maughold, (*) in the shape of a fine boulder of the highly characteristic Porphyritic Pitchstone of Arran. The identity of the rock is avouched by so high an authority as Professor Zirkel.

IX.—THE DRIFT DEPOSITS.

The drift deposits of the Island are of great complexity, and have a development not to be surpassed by those of any part of the United Kingdom with which I am acquainted. The abundance of good sections along the coast and inland enable their characteristics to be made out with exceptional ease. Despite this, however, the only classification which I have as yet found practicable is a rough one into a high-level and a low-level series, with local modifications of the latter to which tentative names may, as a matter of convenience for reference, be applied. Anything in the way of a general correlation does not appear to be possible; and, indeed, the more I reflect upon the matter the deeper grows my conviction that the Manx drift forms one great irregular series, and that such peculiarities as might seem to justify the adoption of some system of classification are ascribable to local, and often temporary causes, which may have operated many times in succession on the same spot, or, by the repetition of similar conditions, have brought about a similarity of arrangement or structure in deposits laid down at two spots remote from each other, and separated by a wide interval of time.

THE HIGH-LEVEL DEPOSITS.—The remarks which follow apply more especially to the deposits in the northern hill cluster, with which I am most familiar, but they will apply, I believe, in some measure also, to those of the southern chain.

The hills are almost entirely swathed in a great sheet of a slate-coloured clay, crowded with chips and fragments of clay-slate rock, with which are intermingled, in smaller proportions, masses of a grit or quartzite and some milky vein-quartz, all these being materials making up the solid subjacent rocks. Some of the included blocks are of very large size—up to five tons, or even more. They occasionally, though rarely, bear signs of glaciation.

This deposit fills in all the valleys, and mantles the hills to such an extent that it is rare to find a bit of live rock peeping out, even on the highest hills. This is the cause of that singular sameness of feature which pervades so much of the Manx upland scenery, and, while robbing it of many charms, invests it with a new and peculiar one.

Magnificent sections are displayed in the lovely glens which descend the hill sides, and among these I would particularise the glen near Corrany, and that which descends to the village of Agneish where the stream has cut a straight-sided gash through Drift deposits to a depth of fully 30 feet. Other fine sections are to be seen in the little corries which seam the eastern flanks of North Barrule, and in the upper parts of some of the glens about Kirk Michael, notably, Glen Wyllin. These high-level deposits, though characteristic of the high grounds, nevertheless descend to within, in some situations, a very short distance of the sea, and in one case, to be mentioned in the sequel, I believe that they are actually exposed on the coast. Everywhere in the north of the Island they are characterised by an absence of foreign erratics such as I shall show are so common in the low level series.

---

* Brit. Assoc. Rep. on Erratic Blocks, 1891, p. 298.

The absence of foreign stones is a most striking fact, and one upon which comment has been passed by Dr. Tellet, though he, relying upon a statement of Mr Campbell of Islay, has supposed that the absence is not absolute. Mr Campbell said, in his "Frost and Fire," p. 172, that on a col between Snaefell and the Mullagh Ouyr, at an altitude of 1,400 feet, he had found yellow and red Sandstones and a rock containing Schorl. I have visited the spot and taken precisely the route followed by Mr Campbell, with the result that after most carefully examining the sections mentioned by him, I can affirm with perfect confidence that the rocks are all of insular origin, and not foreigners, as Mr Campbell supposed. The best sections are along the east side of Snaefell. In one by the roadside, about S.E. from the summit, and just where the road crosses by a bridge a feeder of the Laxey river, I saw the following beds:—Beneath the turf (1) a loose rubble of angular fragments, resting on (2) a mass of red clay, the colour of new leather. The stones include clay-slate, quartz, and a micaceous rock, exactly like that forming the contact zone of the Dhoon granite at Rhenab. Some of the fragments of the last-named rock contained well-developed crystals of a prismatic mineral, which, I do not doubt, is the "Schorl" of Mr Campbell. Dr. Burghardt informs me that it is Tremolite. I have never met with this mineral in the Dhoon slates, but the identity of the matrix—a very peculiar one—is complete. The red and yellow sandstones are simply the grits, which occur so abundantly interstratified between the Skiddaw slate.

The high-level beds vary in texture and contents, being, in general, clay presenting the characters already described; but in many places a gravelly deposit is to be seen—as, for example, on the roadside over the upper entrance to the Tholt-y-Will grounds, to the westward of Snaefell; again, in Glen Helen, where many splendid sections are displayed. An exposure about 200 yards below the Glen Helen Brickworks shows about 30 feet of very sandy material, which in some parts consists entirely of sand. What has struck me as being very remarkable is the absence of those winding ridges and tumulus-like mounds of sand and gravel which are common in many parts of Britain.

In the southern half of the Island, the high-level drift does not appear to be nearly so clearly defined as in the northern region. The clays are as a rule more gravelly, and there are certainly exceptions to the rule that foreign rocks are absent, thus, at the gate to the Peel Waterworks, near Slieu Whallian (see ante), I found a block of one of the Galloway granites, measuring 4·6 × 3·0 × 3·6. It lay evidently undisturbed with its long axis about N. by E. and S. by W. If this be its true position, it would indicate the movement of a mass of ice from about Whitestrand, and I have already mentioned the occurrence along with it of red sandstone, which might have come from the coast thereabouts. On Slieu Whallian itself, just below the second letter "l" in "Whallian" on the one inch map, another large block of Galloway granite upwards of a yard in length lies in the angle between a stone wall and a sod fence. I have never met with a fragment of foreign rock, however small, on South Barrule, Cronk-na-Irey-Lhaa, nor Cronk-Fedjag.

I may mention that I have made repeated excursions in the northern hill regions expressly to find, if possible, any foreign stones.

THE LOW-LEVEL DEPOSITS.—(*A.*) *Of the North.*—The magnificent series of cliff sections extending with little interruption from the Mooragh at Ramsey to Port Cranstal offers a subject for study of—in my experience—unsurpassed interest. The Ramsey Brooghs (Fig. 1.) exhibit the following sequence of deposits very clearly, but the lowest member is rarely well exposed:—(1) A lower bed of boulder-clay fairly well characterised by a dun colour, the occurrence of large quantities of small stones, frequently very well scratched; and, besides these, a great abundance of shells in a fair state of preservation occur. The base of this bed has not been observed. It is succeeded upward by (2) a bed of sand, about 20 feet in thickness, showing false bedding on a small scale, but the larger features are certainly suggestive of regular and horizontal stratification. Occasional seams and patches of gravel occur, and in these (*especially*, though not *exclusively*) shells occur. These may be conveniently referred to as the Mooragh sands. The top of this series has a very peculiar scalloped appearance where it is covered by (3) a bed of yellowish boulder-clay containing few stones and occasional shells. Over all there is an intermittent deposit of gravel, which may be glacial or post-glacial, and which, in its turn, is overlaid by a sandy soil containing Neolithic implements. Similar beds are displayed in the "Brooghs" beside the Sulby river at a ford and footbridge about half a mile west of Ramsey; but the lower bed of boulder-clay is not visible. The upper bed of boulder-clay is here about 10-12 feet in thickness, and a brief search yielded indications of marine shells. The Mooragh sands are shown to a thickness of about 30 feet, and contain many shell-fragments. At Riversdale, in sands met with in a well, several specimens of *Nassa serrata* Broc. (*N. reticosa* Sow.) were found.

When the beds are traced to the northward, an unfortunate interval of grassy talus interrupts the continuity of the coast section, and when that is passed, a different phase is apparent, which I have been unable to correlate with the deposits just described. The cliffs mount to a great height (270 feet), and appear to be composed of boulder-clay in the lower part, and, in the upper part, appears an immense series of sands and gravels containing many shells and shell fragments.

The boulder-clay presents some very remarkable variations of texture, but still more so of contents. As to texture, it varies from tough stony till to fine buttery clay with few stones, and in one place a bed of fine rather tough clay was met with which differed from all the drift-beds of the Irish Sea basin with which I am acquainted, in containing well-preserved shells, which evidently constitute a genuine Boreal fauna, either *in situ*, or at least embedded in the materials which constituted the sea-bottom upon which they lived. Many of the bivalves have the valves still in apposition, and even the epidermis is preserved in certain cases. It is especially worthy of notice that this particular bed of clay contains, so far as I could see, no stones, scratched or otherwise; but there were one or two seams of gravel in it which seemed to show signs of having been involved in the clay by some kneading or shearing movement subsequently to its formation. One of these gravelly seams contained almost as many shells as stones—mostly species of *Trophon* such as *T. scalariforme* and its kindred.

The clay series as a whole is much disturbed, and in the beds of sand and gravel which are included in many places, there are indications of great irregularities of deposition, especially a tendency to arrangement in great pockets and hollows. (See fig. 2.)

It is important to notice in this section, that there is an appearance of bedding in the boulder-clay, which is roughly conformable to that of the gravels, but the sketch undoubtedly gives too great an appearance of regularity to the whole series. The clays and gravels present the appearance of having been worked into one another. The sand and gravel series exhibits the greatest confusion of bedding, but whether the features should be attributed to marine, or to stream, action is a question that cannot in the present state of our knowledge be positively decided from the appearance of the beds. When I first saw the cliffs I was disposed, as others have been before me, to regard them as a great marine beach or bank, but there are, besides those stratigraphical features alluded to, peculiarities observable in the way they are heaped up into hills which do not accord with that explanation. These beds, which I may term the Shellag Sands (from Shellag Point, where they attain their maximum development), contain a considerable number of marine shells, usually in a fragmentary condition; but there is a natural tendency to exaggerate their abundance, as the beds are so well exposed that a large number of specimens may be collected in the course of a day's work upon the great talus which forms a natural sorting apparatus. It should also be remarked that irregular masses and beds of boulder-clay occur in this series.

The fauna in the Shellag sands is of a singularly mixed character, containing, besides some Boreal forms, many species characteristic of warmer waters, and—which distinguishes the Shellag sands from the clays, so far as I know them—a notable percentage of extinct species of Mollusca. These, with one or perhaps two exceptions, are shells found elsewhere in the Pliocene deposits, especially the Red Crag. All, or almost all, the species are found also in the Mooragh sands, in the neighbourhood of Ramsey. There is one distinction which I have observed between the Shellag sands and the so-called "Middie Sands" of Lancashire, and which also would appear to distinguish them from the Mooragh sands, namely, that they contain many boulders of large size, even up to eight or ten tons weight.

The surface of the country occupied by the Shellag sands presents some very striking features, which are evidently directly related to the mode of deposition of the beds. From Shellag Point they extend as a complex chain of hills of remarkably rounded form, each one, as a rule, standing very distinct from its neighbours, and revealing, when a chance cutting has been made, a *bedding parallel to the surface*. The hill-chain rises abruptly from a singularly level country, and extends with little interruption a length of about three miles from the east coast.

The surface of these hills must have been at one time plentifully bestrewn with large boulders, judging from the number which have been employed in the farm buildings, and those which still lie upon the ground.

Many of these stones are of very large size.

The description given of the great Terminal Moraine of the North American continent, accurately describes many of the characteristic appearances of these hills, and the resemblance could hardly fail to strike an observer. On the north-west coast of the Isle of Man, sections are displayed in the long stretches of cliffs exposing the drift in a wonderful manner. The deposits exhibit many features which would I think bring them into relation with those of the Shellag cliffs. The northernmost of my sections is at Jurby Head, where the development is displayed represented in fig. 3.

The lower bed of boulder-clay is very sandy, and, at a point about 50 yards from the section in *fig.* 3, a very interesting set of facts came to light upon a careful examination of the boulders contained in the lowermost part. Stones, from the size of a walnut up to blocks as big as a man's head, were so closely packed in a red sandy clay that, by actual counting, in a square yard of surface there were more than 100. At the very base of the section 75 per cent. of the stones were red sandstone, and, though the rock is soft, a large proportion of them were quite sharp and angular. In the space

vermicular chlorite. At Dhoon a great intrusive boss of granite occurs, of a greyish tint, with a strongly-marked sheared aspect. It contains a brown mica, disposed in a gneissose arrangement. Round about this mass very well-marked contact-metamorphism has taken place, and the curiously altered rocks are traceable with tolerable certainty in the Manx drift.

On precisely the same parallel near the west coast a very handsome compact blue-grey quartzite crops out at a place called "The Carrick," on Skerestal-Mooar farm. Further south, at Rockmount, Poortown, between St. John's and Peel, a splendid dark green rock, with very large Augite crystals, is exposed in quarries. It has been called by the late Prof. Carvill Lewis a Pikrite. Near Crosby another Igneous outcrop occurs—a quartz-porphyry, I believe.

The next Igneous rock to put in an appearance in the southerly direction, is the well-known granite of Foxdale. It is a huge boss cropping out all over "Granite Mountain" (657 feet above O.D.); and it is met with in the lower levels of the Foxdale Mine. The rock is easy of recognition, being quite unlike any other granite in the Irish Sea basin. It is a white granite, without any one constituent standing out in especial prominence, and—which distinguishes it from most of the granites of Galloway—the felspars are not well formed. The mica is silvery white to pale-brown in colour.

Another small patch of granite has recently been discovered in Santon Glen. It is white, and of a fine texture; but not sufficiently well characterised to be readily, if at all, distinguished from some varities of the Creetown granite.

In the Langness Peninsula, and near Balladoole (Bay-ny-Carricky), dykes of, apparently, Pre-Carboniferous age penetrate the Skiddaw slates; and at the former locality masses of "greenstone" also are found. For a description of the latter and of the marvellous series of volcanic rocks at Scarlett Point, I must refer readers to the paper by Mr. Bernard Hobson, M.Sc., F.G.S.*

It will be seen from the foregoing rough outline of Manx geology, that there is no lack of those igneous rocks of which the glacialist makes so much use in the study of boulder-transport; and if, in the ensuing pages I am compelled to be silent regarding the distribution as erratics of some of them, it must be understood that it is from absolute default of evidence.

IV.—Transport of Local Stones.

The enumeration of the well-characterised igneous rocks mentioned in the last section would arouse in the minds of many glacialists the expectation that critical facts would be brought to light when the distribution of their fragments as boulders came to be studied, facts fraught with the issues of life and death to the great theories of glaciation which are at present before the world. We are, unfortunately, at present but ill-informed upon the subject, though, happily, there are able workers in the field to whom it may be that these lines may prove helpful; but enough has been—nay had been nearly 50 years ago—done, to place in the hands of geologists one of the most potent arguments furnished by the whole range of knowledge on the subject.

Regarding boulders of the rocks of *Ballure*, *Skerestal*, and *Poortown*, nothing positive is known, but I have very carefully searched the country to the northward of the outcrops, and have never found a fragment of any of them.

The Carboniferous Rocks of the Peel Outcrop.—I have found the sandstones in a section at Peel, (corner of Church-street), at the reservoir

of the Peel Waterworks, and at several places on the way up Slieu Whallian. It will be observed that all these places are to the south of the natural outcrop. An apparent exception is the case, to be described in the sequel, of multitudes of red sandstone and Carboniferous Limestone boulders at Jurby, but Cumming ascribed them, as I should do, to some adjacent submarine outcrop.

---

* Q.J.G.S., Vol. xlvii., p. 432; and "Yn Lioar Manninagh," 1892, p. 337.

The Dhoon Granite is, as I have remarked, a very boldly marked rock very easy of recognition, and I have taken especial pains to trace out, so far as my limited opportunities would permit, the extent of its outcrop and the distribution of boulders from it. The outcrop extends over the moorland known as "The Barony," across to Glen Callan and Dhoon Glen, thence across the Douglas-road, and it is said that an apophysis runs over to Slieu Ruy. So far as I can learn, no boulder of this rock has ever been seen to the northward of the point at which a bye-road from the northward falls obliquely into the Douglas-road just south of Ballelin.* From this point, they are scattered in profusion to, and past, Laxey. Off the main road, I have found decomposed blocks of what I took to be this rock, at Agneish, and at North Baldrine, on the opposite side of Laxey Glen. Quite at the head of the Glen, on the flanks of Snaefell, I found also a rock much resembling that of the "Contact Zone" of the Dhoon Granite. My traverses of this dispersion, were, besides journeys along the line and to the northward, a walk up the valley from Corrany to the higher lead mines, then over the col between Slieu Lhean and Slieu Ruy, down to Agneish and Laxey, and again from Laxey via Cronk-y-Vaare to Snaefell, and along North Barrule to Ramsey. It will be observed that no boulders were carried from the Dhoon mass northward, but that multitudes went southward, and some, perhaps, were carried a little to the south-west of the outcrop. I have found one or two boulders of this rock at "The Chasms," near Spanish Head, in the extreme south.

Regarding the *Crosby* rock I have nothing to say.

The Foxdale Granite.—The distribution of boulders of this rock has been studied very carefully by Cumming, and his observations have been frequently quoted by writers as illustrations of the action of land-ice.† The granite crops out in a compact boss, forming the hill called "Granite Mountain," which, I am informed, by the Director of the Ordnance Survey, is 657 feet above O.D. The extensive mine working in the neighbourhood renders it in a high degree improbable that there is any other outcrop which has escaped notice, and Cumming said that he had searched unavailingly for signs of such an outcrop (which, by the way, would have relieved him, as he confessed, of a considerable difficulty), and had "inquired for it in vain amongst the miners in that neighbourhood."

Cumming showed that the boulders had been carried in great numbers in a general southerly direction, but my own observations indicate that the main dispersion was to the south-west. From this general direction there were considerable deviations. Cumming notes examples on Langness, the Brough, near Ballasalla, and at Arragon Beg (Santon), which appears to be the most easterly point reached, and says it bears S.E. from the granitic boss, but the bearing is in fact only a few degrees--10° at most—east of south. From here they sweep in increasing numbers round to Port Erin, where they are very abundant, and on via Fleshwick Bay to—according to Cumming—Dalby Head. This last point is rather doubtful, for the author

vermicular chlorite. At Dhoon a great intrusive boss of granite occurs, of a greyish tint, with a strongly-marked sheared aspect. It contains a brown mica, disposed in a gneissose arrangement. Round about this mass very well-marked contact-metamorphism has taken place, and the curiously altered rocks are traceable with tolerable certainty in the Manx drift.

---

* The points mentioned are marked on the one inch Ordnance Maps.

† Horne, Trans. Geol. Soc. of Edin., Vol. II., Part III. Tiddeman, Q.J.G.S Vol. xxviii., p. 487.

On precisely the same parallel near the west coast a very handsome compact blue-grey quartzite crops out at a place called "The Carrick," on Skerestal-Mooar farm. Further south, at Rockmount, Poortown, between St. John's and Peel, a splendid dark green rock, with very large Augite crystals, is exposed in quarries. It has been called by the late Prof. Carvill Lewis a Pikrite. Near Crosby another Igneous outcrop occurs—a quartz-porphyry, I believe.

The next Igneous rock to put in an appearance in the southerly direction, is the well-known granite of Foxdale. It is a huge boss cropping out all over "Granite Mountain" (657 feet above O.D.); and it is met with in the lower levels of the Foxdale Mine. The rock is easy of recognition, being quite unlike any other granite in the Irish Sea basin. It is a white granite, without any one constituent standing out in especial prominence, and—which distinguishes it from most of the granites of Galloway—the felspars are not well formed. The mica is silvery white to pale-brown in colour.

Another small patch of granite has recently been discovered in Santon Glen. It is white, and of a fine texture; but not sufficiently well characterised to be readily, if at all, distinguished from some varities of the Creetown granite.

In the Langness Peninsula, and near Balladoole (Bay-ny-Carricky), dykes of, apparently, Pre-Carboniferous age penetrate the Skiddaw slates; and at the former locality masses of "greenstone" also are found. For a description of the latter and of the marvellous series of volcanic rocks at Scarlett Point, I must refer readers to the paper by Mr. Bernard Hobson, M.Sc., F.G.S.*

It will be seen from the foregoing rough outline of Manx geology, that there is no lack of those igneous rocks of which the glacialist makes so much use in the study of boulder-transport; and if, in the ensuing pages I am compelled to be silent regarding the distribution as erratics of some of them, it must be understood that it is from absolute default of evidence.

IV.—Transport of Local Stones.

The enumeration of the well-characterised igneous rocks mentioned in the last section would arouse in the minds of many glacialists the expectation that critical facts would be brought to light when the distribution of their fragments as boulders came to be studied, facts fraught with the issues of life and death to the great theories of glaciation which are at present before the world. We are, unfortunately, at present but ill-informed upon the subject, though, happily, there are able workers in the field to whom it may be that these lines may prove helpful; but enough has been—nay had been nearly 50 years ago—done, to place in the hands of geologists one of the most potent arguments furnished by the whole range of knowledge on the subject.

Regarding boulders of the rocks of *Ballure*, *Skerestal*, and *Poortown*, nothing positive is known, but I have very carefully searched the country to the northward of the outcrops, and have never found a fragment of any of them.

The Carboniferous Rocks of the Peel Outcrop.—I have found the sandstones in a section at Peel, (corner of Church-street), at the reservoir

of the Peel Waterworks, and at several places on the way up Slieu Whallian. It will be observed that all these places are to the south of the natural outcrop. An apparent exception is the case, to be described in the sequel, of multitudes of red sandstone and Carboniferous Limestone boulders at Jurby, but Cumming ascribed them, as I should do, to some adjacent submarine outcrop.

---

* Q.J.G.S., Vol. xlvii., p. 432; and "Yn Lioar Manninagh," 1892, p. 337.

The Dhoon Granite is, as I have remarked, a very boldly marked rock very easy of recognition, and I have taken especial pains to trace out, so far as my limited opportunities would permit, the extent of its outcrop and the distribution of boulders from it. The outcrop extends over the moorland known as "The Barony," across to Glen Callan and Dhoon Glen, thence across the Douglas-road, and it is said that an apophysis runs over to Slieu Rûy. So far as I can learn, no boulder of this rock has ever been seen to the northward of the point at which a bye-road from the northward falls obliquely into the Douglas-road just south of Ballelin.* From this point, they are scattered in profusion to, and past, Laxey. Off the main road, I have found decomposed blocks of what I took to be this rock, at Agneish, and at North Baldrine, on the opposite side of Laxey Glen. Quite at the head of the Glen, on the flanks of Snaefell, I found also a rock much resembling that of the "Contact Zone" of the Dhoon Granite. My traverses of this dispersion, were, besides journeys along the line and to the northward, a walk up the valley from Corrany to the higher lead mines, then over the col between Slieu Lhean and Slieu Ruy, down to Agneish and Laxey, and again from Laxey via Cronk-y-Vaare to Snaefell, and along North Barrule to Ramsey. It will be observed that no boulders were carried from the Dhoon mass northward, but that multitudes went southward, and some, perhaps, were carried a little to the south-west of the outcrop. I have found one or two boulders of this rock at "The Chasms," near Spanish Head, in the extreme south.

Regarding the *Crosby* rock I have nothing to say.

The Foxdale Granite.—The distribution of boulders of this rock has been studied very carefully by Cumming, and his observations have been frequently quoted by writers as illustrations of the action of land-ice.† The granite crops out in a compact boss, forming the hill called "Granite Mountain," which, I am informed, by the Director of the Ordnance Survey, is 657 feet above O.D. The extensive mine working in the neighbourhood renders it in a high degree improbable that there is any other outcrop which has escaped notice, and Cumming said that he had searched unavailingly for signs of such an outcrop (which, by the way, would have relieved him, as he confessed, of a considerable difficulty), and had "inquired for it in vain amongst the miners in that neighbourhood."

Cumming showed that the boulders had been carried in great numbers in a general southerly direction, but my own observations indicate that the main dispersion was to the south-west. From this general direction there were considerable deviations. Cumming notes examples on Langness, the Brough, near Ballasalla, and at Arragon Beg (Santon), which appears to be the most easterly point reached, and says it bears S.E. from the granitic boss, but the bearing is in fact only a few degrees--10° at most—east of south. From here they sweep in increasing numbers round to Port Erin, where they are very abundant, and on via Fleshwick Bay to—according to Cumming—Dalby Head. This last point is rather doubtful, for the author

---

* The points mentioned are marked on the one inch Ordnance Maps.

† Horne, Trans. Geol. Soc. of Edin., Vol. II., Part III. Tiddeman, Q.J.G.S Vol. xxviii., p. 487.

horizon, and hence the list which I give cannot be regarded as even approximately complete for any one bed. The majority of the shells were obtained from talus-slopes, and I have, therefore, entered them in a general list without localising them to a precise stratum. In some cases the shells were found *in situ*, and then have been referred to their proper position in the sequence.

In the determination of some of the more critical species, I have had most valuable aid from Mr. R. Bullen Newton, of the Geological Department of the British Museum, acting in concert with the well-known authority upon recent Conchology, Mr. Edgar A. Smith, also of the British Museum. If, in regard to the affinities of two shells, I have spoken with a little more confidence than they have, I can only plead as an excuse for my temerity the close familiarity which I acquired with certain of the Pliocene shells during a period of several years of unremitting work upon the English crag deposits.

	I, Cumming.	II, Forbes.	III, Kendall.	Boulder Clay, Lower Mooragh.	Mooragh Sand.	Boulder Clay, Upper Mooragh.	Shellag Sand.	Shellag Clay, "The Church."	Glen Wyllin.	Cliffs, N. of Peel.	Northern.	Recent British.	Southern.	Extinct.
				A	B	C	D	E			F	G	H	I
1. Anomia ephippium, L.			X	X							X	X	X	
2. Ostrea edulis. L.			X	X			X				X	X	X	
3. Pecten opercularis, L.			X				X		X		X	X	X	
4. Pecten maximus, L.			X		X						X	X	X	
5. Mytilus edulis, L....			X	X	X		X		X		X	X	X	
6. Yoldia (Nucula) pygmaea Münster in Goldfuss, 1837. Nucula gibbosa, James Smith, 1839. Mem. Wernerian. Nat. Hist. Soc., 1839, vol. 8, pl. 2, fig. 10, p. 107. [In Forbes's list as Leda pygmaea Goldfuss, Nucula gibbosa, Smith; N. tenuis, Phillippi; N. lenticula Möller].—(Identified by Messrs. R. B. Newton and Edgar Smith.) Fig. 23			X					X			X	X	?	
7. Nuculana (Arca) pernula, O. F. Müller, 1779. [In Forbes's list as Leda rostrata Lamk. Nucula oblonga, Brown].—(Identified by Messrs. R. B. Newton and Edgar Smith.) ...	X		X	X	X		X		X	X	X			
8. Nuculana (Arca) minuta, O. F. Müller, 1776; var. tumida, H. P. C. Möller, 1842. Zool. Danicæ, 1776, p. 24, No. 2,985. Index Molluscorum Greenlandiæ, 1842, p. 17. [In Forbes's list as Leda minuta Fabr.]—(Identified by Messrs. R. B. Newton and Edgar Smith.) Fig. 22	X		X								X	X	X	
9. Nucula nucleus, L.			X				X	X			X	X	X	
10. Pectunculus glycimeris [in Forbes's list as P. pilosus, L. = P. variabilis.] ..	X	X	X	X	X		X				X	X	X	
11. Arca lactea, L.—(Identified by Messrs. R. B. Newton and Edgar Smith.) ...			X					X				X	X	
12. Cardium echinatum, L.		X	X		X		X		X		X	X	X	
13. C. edule, L.	X		X	X	X		X				X	X	X	
14. C. lævigatum, L. = *C. Norvegicum* Speng.	X	X												
15. C. Norvegicum Speng.			X				X				X	X	X	
16. Cyprina Islandica, L.	X		X	X	X				X	X	X	X		

	I. Cumming.	II. Forbes.	III. Kendall.	Boulder Clay, Lower Mooragh.	Mooragh Sand.	Boulder Clay, Upper Mooragh.	Shellag Sand.	Shellag Clay, "The Church."	Glen Wyllin.	Cliffs N. of Peel.	Northern.	Recent British.	Southern.	Extinct.
				A	B	C	D	E			F	G	H	I
17. Astarte elliptica Brown. — A. gairensis Nicoll. — A. sulcata var. elliptica Brown	X		X	X	X				X	X	X	X		
18. A. compressa Mont.	X		X	X	X						X	X	X	
19. A. danmoniensis Lamk. — A. sulcata Da Costa and S. V. Wood	X	X										X	X	
20. A. pisiformis S. V. Wood. This is inserted in Mr. Cumming's list on the authority of Mr. G. B. Sowerby...	X													X
20A. A. sp. A small species with concentric grooves and a rounded form, very like the sub-genus Woodia, but not agreeing with W. *digitaria.*—(A single specimen.)			X							X				X
21. A. borealis Chem. = A. Artica Gray...	X		X	X			X			X	X			
22. Artemis exoleta, L.	X	X	X		X						X	X	X	
23. Venus casina, L.	X		X								X	X	X	
24. V. gallina, L.	X										X	X	X	
25. Tapes decussatus, L.	X										X	X	X	
26. Tellina balthica, L. — T. solidula, Turk.	X	X	X	X	X		X		X	X	X	X	X	
27. T. calcarea, Chemn.—A single fragmentary specimen.)			X							X	X			
28. Donax sp.			X								X	X	X	
29. Mactra solida, L. — M. ovalis, Sow. — M. elliptica, Brown. — (Very abundant at Peel.)	X		X				X		X	X	X	X	X	
30. M. subtruncata, Dac.			X	X							X		X	
31. Lutraria sp.			X											
32. Corbula gibba, Olivi. — C. Nucleus, Lamk.	X		X		X				X		X	X	X	
33. Saxicava rugosa, L.			X	X							X	X		
34. S. arctica, L.			X								X	X		
35. Glycimeris (Panopæa) Norvegica, Speng. — A single fragmentary specimen.)			X	X	X						X	X	X	
36. Mya truncata and var. Uddevallensis, Smith			X		X					X	X	X	X	
36A. M. arenaria, L.			X						X		X	X	X	
37. Pholas crispata, L.			X	X							X	X		
38. Dentalium abyssorum, Sars.											X	X	X	
39. D. entalis, L.	X	X	X	X							X	X	X	
40. Patella vulgata, L.	X		X	X							X	X	X	
41 Acmæa (Patella) virginea, L.—(A single fragmentary specimen.)			X				X				X	X		
42. Cemoria (Puncturella) Noachina, L. ...			X					X			X	X	X	
43. Lacuna divaricata, Fabr.			X		X		X				X	X	X	
44. Littorina littorea, L.	X		X	X	X		X				X	X	X	
45. L. obtusata, L.			X		X				X		X	X	X	
45A. Trochus sp., an immature shell ...			X											
46. Turritella terebra, L.	X		X	X	X		X		X	X	X	X	X	
47. Natica. = N. monilifera, Lamk, catena Da Costa			X		X						X	X		
48. N. clausa, Brod. and Sow.—(A single fragmentary specimen.)	X		X	X							X			

	I. Cumming.	II. Forbes.	III. Kendall.	Boulder Clay, Lower Mooragh.	Mooragh Sand.	Boulder Clay, Upper Mooragh.	Shellag Sand.	Shellag Clay, "The Church."	Glen Wyllin.	Cliffs N. of Peel.	Northern.	Recent British.	Southern.	Extinct.
				A	B	C	D	E			F	G	H	I
49. N. Grœnlandica (Beck), H. P. C. Möller, 1842.—(A single fragmentary specimen.)			X							X	X	X		
50. Admete viridula, Fabr.			X				X				X			
51. Trichotropis borealis, Brod. and Sow. ...			X				X				X	X		
52. Aporrhais pes-pelicani, L.			X		X		X				X	X	X	
53. Purpura lapillus, L.	X		X				X		X	X	X	X	X	
54. Buccinum undatum, L.	X		X	X	X		X		X	X	X	X	X	
55. ,, ,, var. tenerum ...	X				?									
56. B. ciliatum, Fabr.	X										X			
57. Murex erinaceus, L.	X		X		X		X				X	X	X	
58. Fusus antiquus, L.	X		X		X		X			X	X	X		
59. ,, ,, var. contrarius ...			X								X	X	X	
60. F. gracilis, Dacosta			X				X				X	X		
61. F. (Sipho) propinquus ? Alder, 1848.—(A single fragmentary specimen.) ...			X				X				X	X		
62. F. Bamffius	X										X	X		
63. F. clathratus, L. = F. scalariformis, Gould	X		X	X	X		X	X	X	X	X			
64. F. Fabricii, Beck. = F. craticulatus, Fabr.											X			
65. F. Sabini, Gray. = ? F. (Sipho) propinquus	X										X			
66. F. Forbesi, Strickl. (*Vide* Jeffrey's Brit. Conch., vol. IV., p. 296. " = *Buccinum plicosum*, Menke = *Fusus cinereus*, Say = *F. Forbesi*, Strickland. Isle of Man (Forbes): Arctic Ocean and United States") ...	X	X	X		X		X					?		X
67. Nassa reticulata, L.	X	X	X				X				X	X	X	
68. N. incrassata, Müll. = macula, Mont.	X		X		X		X				X	X	X	
69. N. Monensis, Forbes	X	X	X		X		X							X
70. N. serrata, Brocchi. = N. reticosa, Sow. = N. pliocena, Strickland ...		X	X		X		X							X
71. Nassa Kermodei, *Sp. nov.*			X		X		X							X
72. Pleurotoma (Bela) turricula, Brocchi, 1815	X	X	X		X		X				X	X		
74. P. lævigata, Phil....												X	X	
75. P. pyramidalis, Ström.			X		X		X				X			
76. Columbella sulcata, Sow.				X										X
77. C. (Mitrella) sp.			X											
78. Mitra sp.			X		X									X
79. Rissoa sp.			X				X							
80. Cypræa europæa Mont....			X					X			X	X	X	
81. Bulla ? ("Fragmentary shell belonging to the Bullidæ." Messrs. Newton and Smith)			X											
POLYZOA.														
82. Eschara sp.			X	X										
83. Lepralia sp.			X	X										
CIRRIPEDIA.														
84. Balanus communis, Pult.	X													
85. B. uddevallensis, L.	X													
86. B. porcatus, Da Costa				X										
MAMMALIA.														
87. Elephas? A fragment of a tusk was found in the cliffs near Jurby a few years ago.														

No. 20—*Astarte pisiformis*? S. V. Wood.—The record of this shell has been called in question, and I have myself suspected that it was merely a variety of *A. compressa.* I see now no reason to doubt but that it may have been S. V. Wood's *A. pisiformis*, which is probably merely a variety of *A. Burtinii.*

No. 20A.—This shell resembles in form and the aspect of the hinge *line* (the dentition, however, being destroyed) the Crag shell *Woodia digitaria*, S. V. Wood; but, in that shell, the surface is ornamented with spiral incised lines, which proceed from the umbo and cut the margin. In my shell the ornament is in the form of smooth ribs, which are *concentric.*

No. 56—*Fusus antiquus L.*—The majority of these are of the massive unornamented type found in the Northern portions of the British seas, but one or two fragments approximate to the form called Fusus despectus, a species of more than doubtful value.

No. 64—*Fusus Forbesi*, Strickland (figs 4-9).—This species presents many difficulties. It was first mentioned by Forbes in his Malacologia Monensis, and figured as "*Fusus nov. sp.*" Pl. 3, Fig. 1. In 1846, Strickland described the shell (Proc. Geol. Soc., Vol. IV. p. 8) in the following terms:—"3. *Fusus Forbesi*, Strickland, 1843. *Fusus nov. sp.*, Forbes's Malacologia Monensis, Pl. 3, Fig. 1. Middle-sized; volutions about 6, slightly rounded, suture distinct ribs, 11 on first volution, straight, rounded, smooth (perhaps from attrition); interstices concave, hardly wider than the ribs. First volution with about 15, second with about 7 distinct, rather irregular spiral striæ, of which those on the first volution are alternately large and small. They are only visible in the interstices of the ribs. Aperture ovate, double the length of the canal, which is straight, and rather oblique to the left. Pillar lip smooth, with one obscure denticle at the posterior end. Outer lip with about 10 small linear denticles within, continued a short way into the mouth, and a well-marked external rib remote from the margin. Total length, 1 inch 3 lines; first volution, 7 lines; breadth, 8 lines; angle of spire, 43°. *Obs.* This species belongs to the group of *Fusus*, which seems closely allied to Nassa. First described by Mr. Forbes from a worn specimen found on the coast of the Isle of Man, and supposed by him to be an existing species; but the discovery of additional specimens *in situ* proves it to be a genuine fossil."

Forbes remarks in the Geol. Surv. Mem. ["according to Mr. G. Sowerby, identical with *F. cinereus* of Say an American species synonymous with *Buccinum plicosum* of Menke."] Searles V. Wood (Appendix Crag Mollusca Palæontogl. Soc p. 314) quotes this without comment, and again, later (1st supplement, p. 30), with the observation that he has "not seen the shell from the Upper Tertiaries of the East of England," and adds, "*Buccinum plicosum*, Gould." Gwyn Jeffreys, in his "British Conchology" vol. IV. p. 296, mentions the shell as "*Buccinum plicosum*, Menke = *Fusus cinereus*, Say = *F. Forbesi*, Strickland Isle of Man (Forbes); Arctic Ocean, and United States."

Messrs R. Bullen Newton, and Edgar A. Smith, of the British Museum, make the following remarks upon certain specimens which I submitted to them and which I now figure (figs. 4-9). "The specimens labelled *Fusus Forbesi* do not correspond with Forbes' figure in the 'Malacologia Monensis,' Pl. 3. fig. 1. They are not determinable from specimens at the B.M."

Of another specimen they say "*Trophon* allied to *costiferum*, S. V. Wood."

The fact that Forbes's was, as Strickland says, "a worn specimen," will, in part, account for the difficulty of identifying his fig. with my specimens, but Strickland's description leaves no doubt upon my mind that the reference is correct. I judge from Messrs Newton and Smith's comment that my shells do not. in their judgment, agree with the American *Fusus* (*Urosalpinx*) *cinereus.* of Say, and this confirms my own opinion. The Manx shell is *extremely* variable as to proportion, shape, and ornament, and had the extreme forms been found in separate deposits, I do not doubt that they would have been described as distinct and exceedingly well characterised species, and very probably even *genera.* Broken specimens are sometimes difficult to distinguish from *Nassa reticosa* (*serrata*). The species is certainly distinct from *Trophon costiferum* S. V. Wood, a shell displaying no tendency to variation

No. 67—*Nassa Monensis*, Forbes (figs. 10-13).—This is an unsatisfactory species. It was first described by Forbes, *without a figure*, in Mem. Wern. Soc. Vol. VIII, p. 62. Strickland described it (loc. cit. p. 8) in the following words:—"Small; volutions about 6, rounded; suture deep; ribs 9 in the first volution, straight, rather distant, strong, subacute, and slightly oblique. The first volution has 13, and the second 6, distinct, regular, thread-like, spiral striæ, crossing alike the ribs and their interstices. Aperture orbicular-ovate, canal very short and oblique, pillar-lip simple, outer lip with about five slight marginal denticles on the inside, and an external rib slightly more developed than the ordinary ribs. Total length, 7 lines; first volution, 3¼ lines; breadth, 4½ lines; angle of spires, 40°. Obs. Resembles the recent *N. macula*, but is larger, more ventricose, has fewer ribs. and the terminal rib is less suddenly developed."

The late Searles V. Wood also described and figured a shell which he referred to this species (Palæontographical Society, Crag Mollusca, Tab. III, fig. 5), and Forbes concurred in the determination. Searles Wood had three specimens from the Red Crag; but no Manx examples. In the appendix to the work cited he says, p. 315:—"Mr Smith [? Smith of Jordan Hill, P.F.K.] has recently sent me a M.S. note, accompanied with a sketch, by the original discoverer, of what is there called *N. Monensis*, *Nassa*, differing from *N. macula* in having the spire less produced, the body whorl much more ventricose, and the longtitudinal ribs fewer. It appears intermediate between *N macula* and *N. ambigua*, Forbes. The figure presents some considerable differences from the Crag shell, and I regret my inability to get a sight of the Manx shell; they, therefore, must remain united for the present.

In the first supplement to the Crag Mollusca, the author says, p. 15: "*Nassa Monensis*, Forbes, and *N. Pliocena*, Strickland, are still uncertain species. These two shells, originally described by Strickland, are not to be found. Mr Etheridge, of the Geological Survey, kindly endeavoured, with much trouble, to find them, but without success. My own shell (Tab. 3, fig. 3, 'Crag Mollusca,') is probably a var. of *reticosa*. I have not been able to find another like it."

It is much to be regretted that Forbes's drawing was not published, but I quite agree that S. V. Wood's shell is not the same as the Manx species, of which I have 13 specimens. I find that Strickland's description applies exactly to my specimens, which differ from the Crag shell in the possession of 9 costæ instead 10-12, the inner lip or callus extends distinctly further over the body-whorl. and the columella is much shorter. Moreover, the outer side of the columella in the Crag shell is simply striated—in my Manx specimens there is a kind of varix. The "rugosely striated" whorls in Wood's figure seem to have the raised striæ continued over the costæ without change of thickness, whereas in my shells they swell out into knobs. This may be due to the state of wear of the specimens, as it is not observable on the upper whorls to the same extent.

Messrs. R. B. Newton and Edgar A. Smith have favoured me with the following note upon my specimens:—"(21) These specimens are all allied to *Nassa (Buccinum) prismatica*, Brocchi, 1814. The paper label with them gives the identification as *N. Monensis*, but it must be remembered that this is an uncertain species, never having been figured, and type specimens not known. S. Wood in his supplement, p. 15, alters his *Nassa Monensis* to a *var.* of *reticosa*; it is more likely to be a variety of *prismatica*."

In the opinion here expressed I fully concur; but the excellent description by Strickland places the Manx species in an altogether different category from Wood's shell. Nassa Monensis is, I think. clearly separated from N. prismatica, though having affinities with it.

No. 68—*Nassa serrata*, Brocchi, = *N. reticosa*, Sow. = *N. pliocena*, Strickland (figs. 1-3).—This interesting shell has a remarkable history. It was described by Strickland as a new species, *N. pliocena*, in the proceedings of the Geol. Soc, Vol. IV., 1846, p. 8. Forbes includes it in his enumeration of the Pleistocene shells, on the faith of Strickland's determination, though he nowhere mentions having seen the shell. Nevertheless, I do not doubt but that a specimen actually came into his hands, for, in the list of shells, "named by Professor E. Forbes," appended to Cumming's paper in the Q.J.G.S., Vol. II., p. 346, I find mention of "a variety of *Buccinum undatum*? resembling Nassa reticosa."

In 1889, Mr. Roeder, of Manchester, gave me a few shells from the Manx Drift, amongst which was a fine specimen of the boldly costated variety of *Nassa reticosa*. which used to be found in great abundance in the Red Crag of Boyton, Suffolk. I described this shell in a little paper read before the Isle of Man Geological Society, and I mentioned the fact that my lamented friend, Robert G. Bell, F.G.S., had, in a joint paper with myself,* declared the identity of *N. reticosa* with *N. serrata* Brocchi. I understand that this opinion has been called in question; but, not only have I the profoundest respect for Mr. Bell's judgment, but I know that his experience of Nassa reticosa, *in all the varieties* of that protean species, was quite unequalled; and no one, in time to come, can ever equal it, as many of the deposits, from which the best specimens were got, are quite worked out. His knowledge of the Italian varieties of *N. serrata* was intimate, as he not only had the original plates and descriptions of Brocchi, and the works of Phillippi and Seguenza, but also a fine suite of specimens from several localities.

No. 69—*Nassa Kermodei* sp. nov, (figs. 14-17).—Among my shells are 8 nearly entire specimens of a *Nassa*, which I regard as clearly distinct from any known British species, either recent or fossil; and I am unable to identify them with any fossil from any continental tertiary deposit. Messrs. Newton and Smith confirm this view, their comment upon my specimens being: "*Nassa*, probably a n. sp." It devolved upon me to describe the species and propose a name for it. It affords me great pleasure to do honour to a naturalist native of the Isle of Man by naming my shell after my valued friend, Mr. Philip M. C. Kermode.

Description.—Small; volutions about 6, rather flat; suture, very slightly impressed;

---

* Q.J.G.S., vol. xlii., p. 210.

ribs, 7 on the last volution, sharp, distinct, straight; faint traces of close-set spiral striæ between the ribs. Aperture ovate; canal, short and oblique; outer lip with 6 slight, knob-like denticles within; columellar lip simple, with one long obscure denticle defining the posterior canal; callus extending a short distance over the last volution. Length, 8½ lines; last volution, 3½ lines; breadth, 4½ lines; angle of spire, 32°.

Observations.—The shell is easily distinguished from N. Monensis, with which alone of the Manx Nassas it could be confounded, by the more taper form, the smaller number of ribs and their lesser prominence, and by flatter whorls and the general scalariform aspect of the shell.

No. 74 - *Columbella sulcata*, Sow. (fig. 19).—The fragmentary specimen figured is undoubtedly referable to Sowerby's well-known species, though the ornament is much bolder than that of any example from the Pliocenes that I have yet seen.

No. 75—*Columbella* (*Mitrella*) *sp.* (fig. 18).—Messrs Newton and Smith assign this shell to the genus Columbella. I am unable to suggest its specific affinities.

No. 76—*Mitra sp.* (fig. 20).—My reference of this shell to the genus Mitra is confirmed by Messrs. Newton and Smith.

ANALYSIS OF SYNOPTICAL LIST OF MOLLUSCA.

Northern and not British ...	7	Southern and British	3
Northern and British	17	Extinct...	8

XI.—THEORIES.

Many attempts have been made to explain the Glacial phenomena of the Isle of Man, from the time when Cumming wrote his first memoir on the subject; but, until recently, the facts have hardly been sufficiently known to enable a satisfactory judgment to be passed, and even now I feel some reluctance to commit myself to anything more than a tentative working hypothesis to be modified or, it may be, abandoned to make way for a new theory taking a wider view of old facts at the same time as of others yet to be brought to light.

The first theory brought forward was that of the Rev. Dr. Cumming.[*] He accepted the views of glaciation current at the time, and ascribed the low-level boulder-clay and striated rock surfaces to the action of floating ice, operating during a period of partial submergence, while the loose deposits which he found on the hillsides he explained by the then unexploded doctrine of "great waves of translation," which he supposed to have swept the Island from "N.E., or N.E. by E." These views are expressed in his papers in the Q.J.G.S., and are reiterated with more circumstance in his "Isle of Man" (p. 249).

In 1872, in a paper of great value and historical interest, Mr. Tiddeman[†] recited the facts of the distribution of the boulders of Foxdale granite and the directions of striæ, and argued that they are better explained by "the former existence of a great ice-sheet filling up what is now the Irish Sea, between the Lake District and the Isle of Man, and passing over that Island.

1873.—Mr. John Horne, F.R.S., visited the Island and his results, embodied in a paper read before the Edinburgh Geological Society, in February, 1874, were in striking general accord with those of Mr. Tiddeman.

Exigencies of space forbid me to make the copious textual citations that the importance of Mr. Horne's observations and conclusions would warrant; but it must suffice to say that, arguing from the parallelism of the striæ, the character of the deposits, and the derivation of the boulders, he came to the conclusion that a great sheet of land-ice had moved down upon the Island from the mainland of Scotland. The stratified sands and gravels Mr. Horne regarded then as evidence of a submergence of the land during one or more interglacial periods. He suggested the possibility of the existence of local glaciers in the upland valleys "towards the close of the great submergence."

---

[*] I should like here to place on record the high opinion which a perusal of Cumming's papers in the field of his discoveries has inspired in me for the single-hearted zeal and devotion with which he applied himself to the study of all that pertained to the history, geological or contemporary, of his adopted country. I was sorry to see with what neglect and lack of appreciation the geological collection, accumulated by him with such enthusiasm, was being treated in its present abiding-place.

[†] Q.J.G.S., vol. xxviii., 1872, p. 488.

I believe that Mr. Horne has modified his views upon the subject of Interglacial Periods, and of "the Great Submergence"; but to what extent I cannot say.

In 1875 Mr. J. A. Bird published a series of papers in the Geological Magazine (pp. 80, 226, 329, 425) on the Glacial Deposits of the Island; but they added little to our knowledge of the subject, and were mainly devoted to the discussion of the changes of geography which would result from a submergence and re-elevation to the extent of 2,000 feet. No new arguments in favour of such a submergence were adduced, and I may well leave the point for consideration at a later stage.

In 1877 Mr. H. H. Howorth (now Sir Henry H. Howorth, F.R.S.), paid a brief visit to the Island, and collected facts which seemed to show that the conglomerate of Langness, which Cumming regarded as lying at the base of the Carboniferous Limestone, was really a modern boulder-clay, containing limestone erratics.* The admission of this conclusion would have involved an acknowledgment that the great series of Post-Carboniferous dykes in the Island were *Post-Glacial!* Mr. G. H. Morton, F.G.S., in 1879† replied, and had no difficulty in proving that Cumming had not been mistaken in his reading of the deposits amongst which he had lived for so long.

In 1880 there appeared‡ a valuable article by the late J. Clifton Ward, in which the author briefly discussed the Drift deposits. He remarked that the deposits did not differ from those of Cumbria (with which his work upon the Geological Survey had made him thoroughly familiar), and consisted of the usual stiff clay with stones, probably of ice-sheet origin, and sands and gravels, generally of more modern date. The latter, he observed, were mainly developed in the North; and he concluded that they were, for the most part, undoubtedly marine in origin. The contortions and inversions which they display he ascribed to the grounding of ice-bergs. The Drift plateau of the North he regarded as indicative of marine action upon the first-formed Till.

The striations upon the rocks were attributed to the action of floating ice. There was a "great absence" of boulders on the mountain sides; and he saw no cases of large *foreign* boulders on the mountain slopes, or away from the boulder deposits of low levels. Boulders of local rocks (greenstone and granite) occurred in the hills, notably the Foxdale granite.

He was inclined to say that the marks of land-glaciation were few compared with those of marine action; and, though such might be found at some future time, he had seen no trace of local glaciers.

Summarising, he considered it more than probable that the Island had been glaciated by ice-sheets from Scotland and Cumbria, or Scotland alone, which had swept from N. to S., leaving behind the unstratified Till; that then a period of submergence supervened, when the old deposits were modified, and floating-ice, part of the time, brought boulders from Cumbria, and also carried local stones to and fro between different parts of the Island, the shore-line being well glaciated in the process. The author then described the effect of submergence in dividing the Island into a chain of lesser islets, between which strong tidal currents would flow.

Regarding the extent of the submergence, he referred to his papers upon the Glaciation of the Lake District, wherein he gave reasons for believing in a submergence up to the 2,000 foot contour, or even higher, mainly on the evidence of groups of boulders. Similar evidence he considered to be wanting in the Isle of Man for the most part, but he held that the occurrence of Foxdale Granite on South Barrule up to nearly 1,500 feet pointed the same way, for he thought it difficult to see how an ice-sheet from the N. could carry them in a W.S.W. direction to the lee-side of a mountain 700 feet above their occurrence *in situ*, whereas, during a gradual submergence of 1,500 feet, or more, shore-ice could lift and carry them to situations impossible for them to reach if carried by an ice-sheet from the north. Another argument was based upon the entire absence of Alpine plants from the Manx mountains. This would be easily explained if there had been a complete submergence since the maximum glaciation. If Cumbria had been submerged to the 2,000 foot level, why might not the Isle of Man have suffered to a similar degree ; and as Snaefell is only 2,034 feet high the glacial flora would be utterly destroyed.

---

* Geol. Mag., 1877, pp. 410, 456. † Ibid, 1879, p. 213. ‡ Ibid, 1880, p. 1.

I have stated Mr. Ward's facts and conclusions almost in his own words, as they constitute the clearest and most definite statement of the submergence hypothesis as applied to the Isle of Man that I have met with. Other papers mentioned in the bibliography appeared from time to time down to 1888, when Mr. W. Hewitt, B.Sc., recorded* a series of notes on the glacial deposits and markings in the south of the Isle of Man. He described in detail the scratches on the rocks at Scarlet, Poyllvaaish, and Port St. Mary, and showed how at the last place they occurred upon *vertical* as well as upon horizontal surfaces, and expressed the opinion that the effect could be produced only by a sheet of land-ice. He further mentioned some deposits of sandy clay near Port Erin, which, with an example of crushing of the clay slates at right angles to the general direction of ice-flow, he thought might possibly be due to the action of coast-ice.

The next noteworthy contribution was the address of Dr. Tellet, as President of the Manx Geological Society,† in which he recorded some facts concerning the glacial deposits, and discussed the probable sequence of events in the Isle of Man during the glacial period. He considered that the drift-deposits were the product of a great sheet of land-ice moving down upon the Island, and having a thickness of more than 2,000 feet. The boulder-clay would, in his opinion, represent marine stuff, while the sands and gravels were in part the washings of sub-glacial streams, while the remainder, together with an upper boulder-clay, were englacial detritus liberated upon the melting of floating-ice, as the climate ameliorated concurrently with a submergence of the land. Dr. Tellet thinks the Island was wholly submerged, as otherwise he finds it difficult to account for the scarcity of glacial deposits on the higher levels ; "for if we admit that an ice-sheet covered the Island, some of these deposits must have been left behind in the mountain glens and hollows after the ice melted. It seems hardly possible that it could all have been washed down by the glacial streams and mountain torrents ; but the tides and currents flowing and waves sweeping over the Island during the submergence would do so, leaving, however, the larger materials such as boulders behind."

In the papers here summarised three sets of opinions are represented.—(1) That of Cumming which would ascribe everything to the action of water or of floating ice ; (2) That of Mr. Horne and, perhaps, of Mr. Hewitt and Dr. Tellet, which while alloting the most important rôle to land ice, would call in the sea waves and currents to account for the sands and gravels, and one or two facts of distribution, and ; (3) That of Mr Clifton Ward, which assigns but a small amount of work to land ice (though fully admitting its operation) and regarding not only the water-worn detritus, such as sands and gravels of marine origin, but specifically ascribing to the action of floating ice, the remarkable uphill transport of the Foxdale granite, and the almost rigidly parallel striations to the same agency.

---

* Proc. Liverpool Geol. Soc., 1888.

† Trans. Manx Geol. Soc., 1890.

To Mr. Horne's view I at one time myself inclined,* but, subsequent reflection and the accumulation of a great additional body of facts, has compelled me to dissent from the opinions expressed by all who have written upon the subject. This change has been brought about both by my study of Manx geology, and also by my more general work upon the glacial phenomena of the British Isles. †

The opinion which I have deliberately adopted, after a careful examination of all the evidence accessible to me, whether of sections or in the writings of others, is—(1) That our glacial deposits are the exclusive work of either land-ice or of water circulating in or under land-ice or in extra-morainic lakes ; and (2) That our country has not been submerged either during or since the glacial period, except to the small extent indicated by the clearly defined raised-beaches which are so generally recognisable round British shores. (3) That the glacial period was one and indivisible, and that any withdrawal of the ice and readvance over a spot, was merely such an oscillation as is observable in the case of the glaciers of the Alps, and of other places, and was due probably to local and not to secular causes.

The arguments in favour of the land-ice origin of the Manx Drift are, I think, weighty and of cumulative value.

In my descriptions of the features presented by the study of the transport of local stones, I have shown how persistently even those occurring at low levels, such as the volcanic rocks of Langness and Scarlet have been carried in a general N.E. to S.W. direction. The same is the case with the Dhoon granite, without a single recorded exception in either case.

The Foxdale Granite is in some respects a more remarkable case for not only have the vast majority of the erratics from the boss gone in the same direction, but they have in the small distance of two miles undergone a vertical uplift of no less than 828 feet. Mr. Clifton Ward regarded the uplift as a clear proof of the action of floating ice, being doubtless influenced by the fact that Darwin made an ingenious attempt to explain the occasional uplift of boulders above the parent mass by reference to the action of shore-ice. Mr. Darwin pointed out that shore-ice might form around a boulder, say at low-water, then with the rising tide it might carry it forward and strand it higher up a beach, and if the beach were on a sinking area, the boulder might be depressed to low-water and again picked up. Dr. Rae, in the account of his daring exploration of the western shores of Hudson's Bay, describes the way in which huge boulders make their appearance near high-water mark in the spring, which were, in the previous autumn, below sea level. This theory explains what *might* take place, but I have grave doubts whether it *ever did* take place, the chances being enormously in favour of boulders being carried out and dropped in deep water, rather than stranded on a tiny islet at a higher level; but the improbability reaches the extreme point when we find that not one but dozens and hundreds of boulders have been lifted; and, further, that, with the exception of a few stragglers, the stream has been *persistently in one direction.* Mr Clifton Ward overlooked these facts or he would certainly never have drawn the deduction which he did, for he said, in concluding the paper quoted "As the land * * * once more reappeared, glacial conditions returned to a considerable extent, and floating ice laden with stones and boulders played its part in the cold drama, small bergs and floes being wafted *first in one direction then in another** as the currents changed with the varying amounts of elevated land."

---

* British Association Report, 1890, p. 807. † See for many facts and arguments "Man and the Glacial Period,' p.p. 137—181, and Geological Magazine, Nov. 1892.

I would add that, not only would the direction vary with the amount of elevation of the land, but also—as is well-known to all island-dwellers—with the state of the tide, floating northward perhaps with flood and southward with the ebb, and again, vary too with the draught of the bergs. One may read that while the pack-ice of small draught is being hurried down Smith's Sound by the great Arctic or Labrador current, huge bergs towering mast-high rip their way *northward* under the impulse of a swift under-current flowing in from the Atlantic.

The few stragglers from the main stream are easily explained. The Foxdale granite occupies the watershed between the Santon Burn and one of the affluents of the Peel River, and during the early stages of glaciation, blocks of granite would almost inevitably be carried down by river-ice and thrown across the path of the great ice-sheet.

The constant direction of transport of the local boulders, then, constitutes a strong argument against the theory that so erratic a means of transport as floating-ice could have operated, and in my judgment is of itself quite fatal to the submergence.

The extraordinary constancy of direction, too, of the striæ upon rock surfaces in the South of the Island is quite conclusive that the agent which produced them could not have been anything but a great mass of land-ice moving parallel with the main axis of the Island.

The way in which the ice moulded itself to the stepped limestone and striated horizontal and vertical faces at Port St. Mary lime-kilns is inconsistent with the operation of any other agency, and when we find that the long axes of drumlins (hills of boulder-clay) and eskers (long gravel-ridges) coincide with the direction of the transport of local stones and of the striæ, as well as with the evidence of direction of ice-movement indicated by the "aspect of the crags" the demonstration becomes complete. If at any time during the prevalence of the cold conditions, the Isle of Man had been submerged wholly, or in part, I cannot conceive by what conjunction of exceptional conditions all evidence should have been so curiously wanting.

Dr. Tellet raised, in his address, a point of great interest: "How can we account for the scarcity of glacial deposits at high levels"? And he regards it as necessary to invoke submergence to account for the facts; he says, "for if we admit that an ice-sheet covered the Island, some of these deposits must have been left in the mountain glens and hollows after the ice melted," and he suggests that while streams would be incompetent to effect their removal, tides, currents, and waves, would be "leaving, however, the larger material, such as boulders, behind." To the premises I must demur; there is no lack of glacial deposits upon the Manx hills; on the contrary, as I have shown, the upland valleys, and even many of the highest hills, are so completely swathed in glacial deposits that scarcely a bit of live rock is to be seen, and in many places the drift attains a great thickness. There is, however, a very remarkable peculiarity in the deposits at the high levels to which Ward alludes, and to which I made pointed reference in my paper to the British Association, viz., the apparently complete absence of *foreign* erratics at high levels in the northern half of the Island, and the very small numbers to be met with at high levels in the south (I have enumerated them in another section of the paper). Now, if the glacial sea had ever washed the flanks of the Manx mountains and carried icebergs and floes hither and thither, it is quite inconceivable that they should have avoided stranding their rocky freight in some of the straits or on some of the headlands; and once lodged, I cannot imagine any agency which could remove them so completely as to leave not a single one on hillside or valley bottom to tell the tale. Boulders there are by tens of thousands, and deposits by dozens of feet; but not an erratic has rewarded my most rigorous search.

---

* The italics are mine.

This fact is, I think, utterly inconsistent with the marine theory, and for a long time, years even, during which I reflected upon it I found it no less hard to account for upon the land-ice hypothesis. Local glaciers taking their origin in the Manx hills would, it is true, produce deposits consisting exclusively of local materials, but they are put out of consideration at once by the direction of the striæ and all the other indications of the direction of ice-movement. I have attempted an explanation which I put forward with some diffidence, and I can plead on its behalf only that it does not come into conflict with any of the facts of Manx geology, and that it holds the field in the absence of any rival theory. I have commented upon the extremely abrupt northerly acclivity of the mountain axis—especially well seen at Ballure, Claghbane, Sky Hill, and Gob-y-Volley. Now, it is upon this bold front that an ice sheet advancing from the north-east would impinge; and my hypothesis is, that, although glacier-ice can ascend slopes of considerable steepness, there is a certain critical angle which cannot be surmounted, and when that is reached, instead of overriding the obstruction, the ice cleaves and glides past on either side, while, if the obstruction be not very high, the upper strata of the ice will move on over the top.

This kind of action we *know* takes place under modern glaciers, even a large boulder being sometimes sufficient to cause a cleavage, and plentiful evidence exists of such action in the past but particularly I would mention the "deflection-hollows" associated with such a magnificent specimen of "Crag and tail" as the Castle Rock at Edinburgh. If we admit that the ice was split by the abrupt acclivity, how does this help to explain the absence of foreign boulders in the hills?

In this way—the ice which glaciated the Isle of Man was not simple glacier-ice, but *ice-sheet*, ice having its source mainly in the hills of Kirkcudbrightshire, where the whole country would be so covered that not a hill-top remained to shed its debris upon the top of the ice. Hence all the boulders, as I suppose, would be carried in the bottom strata, and the upper layers would be clean and free from rock-fragments. This fact is attested by numerous observers in Arctic and Antarctic regions. It is only in the neighbourhood of Nunataks that stones are ever seen on the Greenland ice. Granted that the ice would cleave in the way suggested, then it would follow that the stone-laden ice would flow away right and left of the obstruction, while the clean upper strata would pass on, and, catching up the loose stones lying on the hills or tearing off masses from exposed crags, would glaciate the Island with its own debris. Accepting this as a provisional or working hypothesis, I examined the hills around Maughold in the expectation that, as *ex hypothesi* the ice which reached there would have had a practicable gradient up which to ascend, I should find foreign erratics up to much greater altitudes than on the main hill-mass above Ballure. This expectation was fully justified in the event. Foreign stones—granites and the like—occur on the highest points in Maughold, while along the Douglas road near Slieu Lewaigue I could not find any but insular rocks.

Since the reading of this paper the Rev. S. N. Harrison has made a series of discoveries which testify in a remarkable manner to his powers of observation, and also supply a striking and wholly unexpected confirmation of my theory. Mr Harrison showed me an undoubted example of a striated rock-surface at the Cronk, near Ballatesson (Ballaterson on the map), Maughold, which according to my determination, was scratched from N. 54° W.

instead of in the normal direction from N.E.; and he has since found striæ at Claghbane, some of which are from N.E. to S.W., while others are from N.W. to S.E. Mr. Harrison has kindly permitted me to inscribe upon the map accompanying this paper, these and many other striæ observed by him. A full account of his discoveries will be found in the Transactions of the Isle of Man Nat. Hist. and Antiq. Soc. 1892-93.

These discoveries certainly lend colour to the theory I have put forward, for it would appear from them that at the northern end of the Island the movement of the ice was nearly at right angles to that of the general mass, and, further, the crossed striæ at Claghbane might be taken to indicate that the place at which the cleavage happened varied from time to time so that striæ were inflicted from almost opposite points of the compass.

I do not claim that my theory is proved; indeed I can see several difficulties in the way of its acceptance, as, for example, its failure to account for the stone-laden bottom-ice passing the mouths of several large valleys such as Glen Auldyn and Sulby Glen, and to the difficulty on this hypothesis of understanding why absolutely *no foreign* boulders rose sufficiently high to be carried into the hill-country. The occurrence of a few foreign stones on Slieu Whallian can of course be readily accounted for by my theory. The general churning of the ice, in closing in the rear of the northern *massif*, and again opening out to cross the southern chain, might easily account for a considerable number of foreigners being worked up in the ice to the level even of South Barrule.

This theory would offer a ready explanation of the interesting section exposed near the mouth of Glen Mooar, Kirk Michael (Fig. 7), where a bed of boulder-clay containing exclusively local stones is seen overlying boulder-clay with shells and foreign stones. This would be a case in which a slight change in the direction of ice-flow brought the products of the upper strata across ground previously occupied by the lower elements of the ice-sheet. Again, the curious banking of the deposits against the old cliff at Ballure Glen, would be explained in a similar way. The Glen Mooar section I was at one time inclined to interpret as the result of a conflict between local glaciers and foreign ice; but the facts of boulder-transport and other indications of the direction of ice-movement seem to strongly oppose such a view; nevertheless, if I had to select the spot in the Isle of Man where local glaciers would be most likely to form, I should certainly select the deep hollows on the western slopes of Slieu Freoghane and Sartfell.

It now devolves on me to attempt an explanation of those features of the low-level drift which have induced many observers to regard it as of marine origin. The occurrence in the glacial series of beds of sand and gravel would at one time have been regarded as conclusive proof of marine conditions. We now know, however, that streams of water course under all great masses of land-ice, whether Alpine glaciers or Continental ice-sheets of the Greenlandic type, and running water, whether exposed to the light of day or not, will always have the power of grading materials, carrying in perfect suspension the finest clay particles, hurling along the sand-grains, and perhaps larger masses, and slowly rolling the gravel stones. With any variation of the velocity of a stream its carrying power will vary yet more, and a diminished current will drop the materials of large grade and produce a bed of sand or gravel. Now, the sub-glacial streams have their time of flood in the summer, and in the winter their period of dwindling, when sand and gravel banks will be formed in the almost deserted channels. Some stream-courses will doubtless be abandoned completely, the icy walls will press in, and the next deposit, if any, to be laid down will be the ground-moraine or mingled unsorted debris of all sizes and kinds, which is dragged beneath land-ice where no water is flowing to act as a vehicle. It might be thought that such loose materials would be torn up by the movement of heavy ice-masses overhead, but, though we cannot assign precise reasons for the apparently capricious way in which glacier-ice behaves—here gliding over soft sandy beds without disturbing the stratification, there ploughing, or rather rasping, huge furrows in hard and tough rocks—still the fact is patent that ice does thus behave.* By means such as these I would explain many of the beds of stratified sands and gravel found in the Manx drift, but some of them may be of morainic origin, or may have been laid down by water washing freely out from the edge of the ice, and laying down great fans of gravel or sand. As an example, probably, of the latter case, I would mention the gravels of the singular plateau near Kirk Michael, which bear a strong resemblance, in my opinion, to the gravel sheets called by the American glacialists "kame-deltas." And I would here say a few words regarding the kames or eskers,† and at the same time deal with an interesting question raised by Mr. Horne. In the paper before quoted, he ascribed the great accumulations of clay, sand, and gravel which cap the glacial series of the north of the Island to what he terms "the Kame series," and he regarded them, in conformity with the views prevailing at the time when he wrote (1874), as of marine origin ; and, therefore, evidence of a considerable submergence of the country at the close of the glacial period. With his ascription of these deposits to a "Kame series," I am, on the whole, disposed to agree, but to regard that series as of marine origin is quite another thing. I may explain that, where typically developed, Kames are ridges of gravel and sand taking a sinuous course over a country, and frequently disregarding the lesser, and even some of the greater, physical features. Thus thev will sometimes run in straight lines descending deep valleys and crossing lofty hills. They frequently broaden out into a plexus of hills, enclosing within their ramifications small lakelets, or in some cases dry hollows without any drainage outlet. It has been pointed out that no marine sand or gravel banks could by any known conjunction of causes be thrown up in such a fashion. Thus, it is quite contrary to every observation upon marine currents to suppose that they could lay down a steep-sided ridge of gravel crossing a valley 1,000 feet deep as Kames are known to do. Their relation to the known line of ice-flow is such as to show that there must be some causal relation between the two phenomena. The marvellously developed Kame series of Sweden, of the New England States, of Ireland, and the lesser examples in England, Scotland, and Wales, have been shown to run in parallelism with the movement of the ice-sheets in those regions. This constancy of direction cannot be fortuitous, and the American geologists have fully recognised that the explanation of the origin of Kames must be sought, not in the behaviour of marine currents, but in the conditions of drainage of the peripheral portions of ice-sheets or glaciers. Observations made by Russell upon the great Malaspina glacier show that sub-glacial streams flowing through icy walls deposit gravel in ridges and knobs, the latter being produced where the roof of a tunnel locally breaks in. It will readily be understood that such streams will flow towards the free front of the glacier, and consequently parallel to its path. The observations which have been made upon the Greenland ice-cap by Dr. Rae, Baron Nordenskiold, and Dr. Nansen, give us a great deal of insight into the conditions of sub-glacial drainage beneath that great ice-cap, as I have suggested above. Streams of muddy water emerge from beneath the glacier winter and summer; but during the summer-time their flows must be enormously augmented by the superficial melting of the ice. Baron Nordenskiold saw rivers coursing over the surface of the ice, and plunging down crevasses with a prodigious roar into the abyss beneath. Now, it is clear that, inasmuch as the water escaping through sub-glacial channels into the ice-fiords is extremely turbid with suspended rock-meal, the base of the ice must be shod with boulders whose attrition with the live rock produces this detritus, and if there be boulders, stones of lesser sizes must be swept along by the sub-glacial streams. Now, it seems to me an inevitable corollary to this conclusion that, as the summer volume of the sub-glacial streams is augmented to so enormous an extent by the descent of super-glacial water, directly the summer sun loses its power, and the frost silences the surface streams, then the sub-glacial channels which were adequate to carry off the entire drainage will, just as we observe with ordinary rivers, be, to a large extent, silted up with the gravel, sand, &c., which the impoverished rivers can no longer bear along, and ridges of sand and gravel, hemmed in between the icy banks, will remain, constituting in fact, "casts" of the rivers themselves, and displaying, in their mode of looping and branching (or rather confluence), just the same features as subaerial rivers would, but differing in this highly significant feature that, as the sub-glacial rivers were flowing through *tubular channels*, they could flow up hill or down hill with almost equal facility. The description of the Irish Kames (or Eskers) given by Professor Sollas* brings out very clearly the agreement between the hypothetical explanation and the observed facts in regard to these remarkable objects.

---

* See Lamplugh, Proc. Yorks. Geol. and Polyt. Soc., vol. ix., part i., p. 57.

† I take this opportunity of uttering a protest against the attempt on the part of a geologist of distinction to impose upon geological literature the Welsh equivalent, "esgair," of this thoroughly well-known and well-established word. If we are to revert to the Welsh orthography of every word of Celtic derivation in our language the type-founders will find an increased demand for "l"s and "w"s, and Manxman and Welshman will wage war over the relative merits of "poyll" and "pwll."

Of actual moraines in the Isle of Man, I can point to but one example, and regarding that I am not without misgivings. The splendid sweep of Drift hills extending from Shellag with small interruptions round to Kirk Michael, display many characteristics of undoubted moraines which I have seen in England and Wales, such as the tumultuous piling of the hills, the bedding parallel to the surface, and the basin-like hollows entangled among some of the hills, still the materials are finer than are usually seen in moraines, and I am quite prepared to accept any other explanation of their origin more in accord with experience. I would here remark that, in a paper read before the Glacialists' Association, in September, 1892, I attempted to show that in some cases morainic hills had been over-ridden by the glacier which produced them, and had received a covering of boulder-clay (the ground moraine of the glacier) without any further interference with their contours than would be caused by the filling in of a few hollows. I see no reason why this process might not be several times repeated, especially in a flat country, and then alternations of boulder-clay, sand and gravel might be produced, such as are to be seen in the great moraine on Flamborough Head, described by Mr Lamplugh, † and such as may be seen in parts of the section at Shellag.

The occurrence of shells in the Shellag series, and in other glacial deposits in the Isle of Man, furnishes no argument against the views here advocated, for numberless cases exist in which it has been proved, as I think, beyond reasonable doubt, that the shells are boulders, in as true a sense as the ice-scratched stones. However, to deal specifically with the Drift of the Isle of Man. The case here is by no means so conclusive as it is in the larger areas of England, Scotland, Ireland, and Wales, in each of which such anomalies appear in the positions in regard to altitude at which shell-bearing drift appears as to show very plainly that no species of submergence and re-elevation could account for their occurrence. Take the two sides of the Pennine Chain, in the latitude of Macclesfield, and, whereas on the Western side glacial deposits containing foreign erratics and marine shells occur up to altitudes of nearly 1,400 feet, on the Eastern side, the country is absolutely free of Drift or of marine deposits or shells, and no trace of either is to be met with until the Lincolnshire fens are reached, when Drift of a wholly different type is encountered at an altitude of about 60 or 70 feet above sea-level. I have shown in the work already quoted* that in the glacial deposits of England and Wales, shells occur *only* in cases where it can be shown upon other evidence that the glacier-ice has pressed in upon the land from sea-ward, my contention being that the shells were portions of shell-banks which had been mangled by the advancing glacier, and portions of which had been involved in the bottom-moraine or in the ice itself. In the Isle of Man, according to my view, the whole glaciation was effected by ice coming in from sea-ward, and hence, previously to reflection on the subject, one might expect upon this hypothesis that the whole of the Manx Drift would contain shells, but I have already stated the grounds of my belief that the bottom-ice, which could, as I think, alone contain the shells, never invaded the high grounds. This is in agreement with the fact that, so far as I know, no shells are ever found above the highest point of the Bride Hills. In the Isle of Man as in England—though for a different reason—the Drift with exclusively local erratics is never found to contain shells.

---

* Brit. Assoc. Report 1893, p. 777, and Glacialists Magazine Vol. 1., p. 119.

† Q.J.G.S. xlvii. p.

If the theory of the submergence of the Manx Hills have not been sufficiently disposed of by the arguments already advanced I might further point to this absence of shells—a peculiarity of all the hill-centres of the British Isles—and to the striking and significant absence of inland beaches, seaworn caves and cliffs, and rocks bored or encrusted by marine animals or plants. These latter features are absent in the Isle of Man, equally from the low grounds and from the hills, and cannot be explained so far as I can see except on the supposition that the sea has never been over the area since Tertiary times. An argument has been put forward by some writers that the submergence was so transient that no marked features could be produced; but the magnitude of the deposits claimed as marine disposes of that, and the further suggestion that sea-beaches are evanescent features is disproved both by the marvellous preservation of many glacial relics, such as kettle-holes (or swamp hollows) and also of undoubted beaches, such as the Parallel Roads of Glenroy, which fringed extra-morainic lakes of the Glacial Period in Scotland.

Turning now to the distribution, nature and condition of the shells, I see in these no less than in the general conditions evidence that the deposits are not marine accumulations :—

In the first place, it may be noted that the shells are found in the greatest abundance just in those places where they would be most likely on the " Push-up " hypothesis to appear, viz., in the low grounds of the North. Shells are distinctly rare in the South, though they have been met with in fair abundance at one or two places near Castletown.

Their distribution in the different classes of deposits is noteworthy. They occur in considerable numbers in boulder-clay, even in the hard Till which is met with occasionally, and it is significant that the species are very much the same as are to be found in the sands and gravels. In one patch of clay, however, which I met with at Shellag, protruding upward into sands and gravels a rich assemblage of shells—relatively to the size of the clay-patch—occurred, including several species, such as *Cemoria* (*Puncturella*) *Noachina*, *Leda minuta*, *Arca lactea*, which I have not found in any other part of the Manx series.

---

* "Man and the Glacial Period" (Internat. Scientific Series), p. 167.

In the sands and gravels shells are *apparently* much more abundant than in the clays, the illusion being a consequence of, the greater facility with which they can be extracted—of their concentration in layers and patches—and of the way in which they roll down the great talus slopes and accumulate at the bottom. By searching the taluses, one might get, in the course of a day's diligent collecting, perhaps half a pint of shells in different states of wear and breakage. The *concentration* of the shells to which I have made reference, is a phenomenon dependent purely on physical causes, and not to be mistaken for the crowding of gregarious species such as mussels or cockles. When materials are exposed to the action of running water, it not only sorts them out according to size, but also according to the specific gravity, not of the material, but of the whole mass; thus, an ordinary cockle-shell is composed of a form of carbonate of lime, having a specific gravity of about 2·9; but there is a series of spaces or pores in the shell occupied either by animal matter or by water, and these will reduce the specific gravity of the whole mass to perhaps 2·0; and the shells will be thus as a whole of lower specific gravity than the pebbles of an average gravel, so that running water will be able to move larger shells than stones, carry them further, and pitch them all down together.

The same kind of action takes place with flotsam and jetsam on our shores, and one may see here corks, there coal-dust, and yonder bits of iron, all of a kind together.

The condition of the shells is strongly opposed to the idea of their being in their native habitat.

Throughout the sands and gravels the shells are, generally speaking, very much worn and broken; and I have not seen a single example of a bivalve having the valves in apposition.

In the boulder-clay met with in the sewer-cutting on the Mooragh (a dark tough clay full of stones) Dr. Tellet* and Mr. Kermode† found two examples of *Tellina Balthica* with the valves united, but this remarkable fact is recorded by Dr. Tellet, though they were taken out of hard grey-brown boulder-clay, the valves were "full of a white siliceous sand, in which * * * I detected some foraminiferæ." Similar facts have been noted by Mr. Lamplugh‡, and Mr. Shone§, and the interpretation is plain, the shells lay in a sandy bed on the floor of the sea, and were involved in the clayey ground-moraine of the ice-sheet when it bore down upon the Island. One other case in which the valves were paired has come under my notice in the fine shelly clay at Shellag. I found several pairs of valves of the delicate *Leda minuta* which even retained their epidermis. I incline to the opinion that the clay in which these shells occur is a portion of the sea-bottom which has been transported bodily. It contained no stones so far as I could see, but the bed and its contents would well repay the careful examination of some observer having more time at his disposal than I had.

The nature of the shells in the drift is strongly confirmatory of the views I have here expressed regarding their origin. There is a mixing of species of diverse habitat quite different from the natural grouping, and, though I do not regard this of itself as in any sense a test, still, having regard to the fact that we nowhere get a pure fauna such as might have lived side by side on the sea-floor, it seems a very strong argument against the marine origin of the beds.

---

* Trans. Manx Geol. Soc., 1890, p. 6. † Yn Lioar Manninagh, No. 4, p. 96.

‡ Q.J.G.S., 1884, p .316. § Q.J.G.S. vol. xxxv., p. 383.

The southern elements of the fauna, though according well with what are to be seen in the corresponding deposits of England, North Wales, and Ireland, are yet anomalies wherever found in the glacial series, if we suppose, as is so commonly done, that they were occupants of a sea in which the Glacial deposits were laid down. The other noteworthy element in this list of shells is the remarkable series of extinct species. Of these, assuming, as I feel justified in doing, that the *Mitra* and the *Woodia* are extinct—we have eight, constituting 10 per cent. of the whole fauna. One of these, certainly, viz., *Nassa reticosa*, as I have pointed out, has long been known in the Pliocene Beds of East Anglia, Cornwall, Belgium, France, and Italy, and from the way in which the species diminishes in numerical representation in the successive zones of the Red-Crag, and is represented in the newer Pliocene deposits of East Anglia, only by remanié specimens, I feel justified in regarding it as a species which in all probability became extinct, in British seas at least, before the close of the Pliocene period. The general aspect of the other extinct species of the Manx drift is southern rather than northern, and these, too, I believe to be Pliocene shells. I have already given some details[*] of the occurrence of Pliocene shells in the British drift deposits, but I may be permitted to recapitulate and supplement this evidence.

The late Mr. S. V. Wood, jun., enumerated many species from the drift of East Anglia. Mr. T. F. Jamieson[†] obtained the following extinct or southern species or varieties from the glacial gravels of Slains and Cruden, Aberdeenshire :—

Astarte mutabilis X.
Cyprina rustica X.
Fusus antiquus v. contrarius S.
Nassa reticosa X.
Nucula Cobboldiæ X.
Panoræpa Faujasii? X.
Pectunculus glycimeris var. X.
Purpura lapillus v. incrassata X.
Trophon costiferum ? X.
Turritella incrassata S.
Venus casina var. X.
Voluta Lamberti X.

A similiar though smaller series has been found by Capt. James and Mr Alf. Bell[‡] in the "manure gravels" of Wexford; viz., *Melampus pyramidalis*, *Mitra* (*cornea?*), *Nassa reticosa*, *Nassa semistriata*, *Turritella triplicata*, *Nassa granulata*, *Fusus menapii*, *Pleurotoma lævis*, *Nucula Cobboldiæ*, *Woodia digitaria*, *Pectunculus pilosus*, besides several southern species not found in the English Pliocenes.

More recently Mr Lloyd Praeger[§] has recorded in the list of shells found by Professor Sollas in the drift of Dublin Bay a *Nassa* which he remarks "is not recent British," which I have pointed out in the *Glacialist's Magazine*,[||] is, in my judgment, a new species, and therefore extinct.[¶]

One general explanation applies to the occurrence of all these shells, viz., that, in common with the rest of the molluscan contents of the drift deposits of the regions specified, they are to be regarded, not as a contemporary fauna of the Glacial period, but as the relics of the Shell banks of various Geological ages gathered up by the action of Glacier-ice traversing portions of the sea bottom which lay in its path, and re-deposited in the sands, gravels, and boulder-clays, where the ice emerged upon the land after traversing the sea-floor. Abundant evidence, in the shape of striated rock-surfaces, and other proofs of the movement of *Glacier* ice (as distinguished from floating ice) is available, to show that the ice moved in upon the land from seaward. Under such circumstances, shells of very diverse age and habitat might be brought together. Pliocene shells, which would include, probably, the extinct and southern species, would be brought into juxtaposition with shells but recently vacated by the occupants of the glacial seas. Shells from the deep water would be mingled with the species which live adhering to the rocks between tides, such as *Purpura lapillus* and *Littorina littorea;* burrowing shells, which would live embedded in mud, would be found along with those whose natural habitat was a sandy or gravelly bottom. It is consistent with this explanation that the shells are usually in a very much broken condition, only the stronger shells, as a rule, surviving the rough treatment to which they have been subjected. The univalves are more commonly found in a perfect condition than the bivalves; paired-valves of the latter being rarely found ; and shell fragments—especially when found in the boulder-clays, and showing no signs of decortication by chemical action—not infrequently being polished and ice-scratched.

---

[*] Proc. Manx Geol. Soc., 1889.

[†] Q.J.G.S., 1882, p. 155.

[‡] Brit. Assoc. Report, 1890, p. 410,

[§] Irish Naturalist, Vol. III, No. 1, p. 18.

[||] Glac. Mag. Vol I, p. 189.

[¶] By Mr, Praeger's kind permission, I am able to give a figure of this shell: see plate 3, fig. 21.

The entire absence from the Manx Drift of shells or stones encrusted with barnacles, polyzoa, or annelid tubes is a further argument against their marine origin. That the demand for the production of such evidence as this, if the deposits be truly marine, is not unreasonable will be apparent, I am convinced, to anyone who has, like myself, worked even for a short time amongst the unquestionable marine post-glacial clays of the Clyde valley. In these deposits a large proportion of shells and erratics are so encrusted. Nor is this peculiarity restricted to clay deposits. In the shelly sands of the English Pliocene series large numbers of shells are found encrusted.

In brief, taking the evidence of the mollusca alone, without any reference to the character or distribution of the deposits, the striated surfaces, the nature, origin and distribution of the boulders, or any of those factors upon which an opinion might be formed regarding the mode of origin of the shell bearing Manx drift, I think the anomalies which I have pointed out—the entire absence of shells in the position in which they lived, the mutilated condition of the specimens, the strange intermingling of shells of different Geological age and diverse habitat, are quite sufficient to show that we are not dealing with marine accumulations of any kind.

XII.—POST-GLACIAL HISTORY.

The freshness of all the glacial features in the Isle of Man attest to the comparative recency of the disappearance of the ice. The morainic and esker mounds, the drumlins, the kettle-holes, and all the other surface features of the Drift deposits retain their sharpness in a remarkable degree. Some interesting oscillations of level appear to have taken place during the short interval of time which elapsed between the final disappearance of the ice and our own times.

Around the south of the Island the occurrence below high-water mark of stumps of trees, apparently rooted in their native soil, has been regarded as proof that the land had once stood higher than at present ; and, notwithstanding the arguments of Mr. Shone, I cannot but think that the subterranean removal of loose materials by springs has played but a small part in the production of such phenomena, either here, or elsewhere, in the British Isles.

Regarding the date to be assigned to these forests, there is a statement by Cumming that at Strand Hall the stumps bore evidence of having been hewn with a stone axe, and this, if authentic, would fix their neolithic age. Regarding the extent of the elevation of the Island, we have no direct evidence ; and, indeed, movements of subsidence, unless succeeded by re-elevation of corresponding or greater extent, do not, in the nature of things, leave us such evidence in accessible positions, except for the evidence afforded by soundings of submerged valleys and of abnormally broad estuaries such as those of Cornwall, Devon, and Dorset. Evidence of this class is entirely wanting in the Isle of Man ; the rivers have comparatively narrow mouths, and soundings do not afford any indications of submerged valleys.

It has, however, been argued as a general proposition, applicable to the whole of the British Isles, that the land in post-glacial times has stood at least 600 feet above its present level, a conclusion deemed necessary to account for the distribution of terrestrial and fresh-water animals and plants. There are, however, remarkable pecularities of the Manx fauna and flora, which seem to me difficult, even impossible, of explanation, if so great an elevation be granted.

It has long been a subject of remark by botanists that the flora of the Isle of Man is an exceptionally meagre one, comprising so small a number of species that many suggestions, including that of total submersion beneath the sea, have been hazarded to explain the facts. Such a suggestion is, however, unsupported by any evidence. Had the country been thus wholly submerged, the Drift features so clearly ascribable to the action of land-ice, must have been obliterated, and their materials re-distributed by the action of the breakers. Raised beaches would, moreover, be found at high altitudes, whereas these signs of depression are, in the Isle of Man, limited to a height of about 20 feet above the present level of the sea. Some other explanation must then be sought. It cannot be found in the physical features of the country, nor in the composition of its rocks, for both the one and the other are extremely varied. Mountain and valley, swamp and level plain, diversify the surface of the land, the drift deposits produce great diversity of soil, while the solid rocks comprise such different materials, as slate and sandstone, limestone, and soft calcareous breccia, granites, volcanic ashes and other igneous rocks, in great variety of structure and composition.

When we compare these features with those of the Channel Islands, which are much further removed from the nearest mainland, we shall find, that in every particular, the Isle of Man is better adapted for the maintenance of an extensive assemblage of plants, than the Channel Islands, yet the former has yielded to the researches of botanists * "At most 450 species, while Jersey has a record of 690."

When the lists of the Manx vertebrata are examined, very surprising facts come to light.

Mr. Kermode † enumerates the following species of Terrestrial Mammalia :—

1. Erinaceus europæus L.	Hedgehog.
2. Sorex araneus L.	Shrew,
3. Mustela erminea L.	Stoat.
4. Mus. sylvaticus L.	Long-tailed Field-mouse.
5. M. musculus L.	Mouse.
6. M. rattus L.	Black Rat.
7. M. decumanus Pall.	Brown Rat.
8. Lepus timidus L.	Hare
9. L. cuniculus L.	Rabbit.

But all these cannot be regarded as indigenous. The hedgehog, the black rat, the brown rat, the rabbit, and possibly the house mouse, have been introduced by chance or design by human agency.

---

* Miss Daw, Y.L.M. ; p. 97.

† Zöologist (February, 1893), 3rd s., vol. xvii., No. 194,

As against these deductions, however, we must add to the list of post-glacial immigrants the Irish elk, which inhabited the country in post-glacial time, but is now extinct.

Of reptiles and amphibia there are but three, viz., two lizards and the frog. The last-named was designedly introduced about the year 1750.

An even more marked deficiency is noticeable with respect to fresh water fishes. Of these, Mr. Kermode enumerates the following :—Three sticklebacks, the eel and the lampern, the salmon, and two species of trout; but it should be borne in mind that salmon, trout, and eels are all fishes capable of habitually resorting to the sea.

Mr. J. C. Crellin* suggests, in explanation of what he terms "the entire absence" of fresh water fishes, the rapid nature of the streams and the gravelly or rocky bottoms of the rivers. I cannot, however, concur in this view. There are still reaches in many of the rivers, and there are many ponds in which such fishes as tench and perch, &c., would find a congenial habitat, while many of the common British fishes live and thrive in very rapid streams.

It seems to me that this extraordinary poverty of truly indigenous species in so many groups of organisms is well worthy of the careful consideration of naturalists and geologists, for, while to the former it presents an interesting problem for solution, to the latter it may not improbably prove of use as a check upon some of his speculations. For my own part, taking this evidence as it stands, the balance of probability seems to weigh heavily against any such complete connection with Great Britain as the oft-cited elevation of 600 feet would establish. The distance from Liverpool to the Isle of Man is only about 70 miles, while the Lake District is even nearer, and the promontory of Wigton approaches within 20 miles of the north of the Island. The intervening seas are extremely shallow, the depth nowhere exceeding 50 fathoms, and it seems to me incredible that, if this whole tract had been dry land during any considerable portion of the post-glacial period, but two out of the 13 reptiles and amphibia which inhabit Britain should have made their way across to the Island; that of the strictly fresh water fishes three only should have been introduced ; and of the 40 British mammals but five should have made their way across. If a land connection was indeed established, it must, I think, have been of very small extent and brief duration.

XIII.—SUMMARY.

The facts embodied in the foregoing sections, and the inferences which I draw from them may be conveniently summarised as follows :—

I.—THE TRANSPORT OF LOCAL STONES.

1.—The rocks of *Ballure*, *Skerestal*, and *Poortown*, are not traceable in the drift to the northward of their respective outcrops.

2.—The *Carboniferous rocks of Peel.* These can be traced in the drift to the southward, but not to the northward of their position *in situ.*

3.—The *Dhoon Granite.* I have found abundant erratics of this rock upon and to the southward of its outcrop, but not to the northward.

4.—The *Foxdale Granite.* Erratics are spread over a triangular area, having its apex at Granite Mountain and its easterly limit at Arrogan Beg (Santon), and its most westerly extension at either Dalby Head or Stroin Vuigh, probably the latter, but the main dispersion has been to the S.W. The boulders have been lifted to altitudes above the parent mass of 828 feet on South Barrule, and 792 feet on Cronk-na-Irrey-Lhaa.

---

* Trans. I.O.M. Nat. Hist. and Antiq. Soc., vol. i., p. 57.

5.—*The Carboniferous and Igneous rocks of the South.* Trails of boulders extend in a south-westerly direction from the intrusive masses on Langness. At Hango Hill, Castletown, a profusion of boulders of a limestone resembling that of Skillicore occurs in the boulder clay. The movement in this case appears to have been from N.E. to S.W.

No example of any of the igneous rocks of Scarlet Point has been found either by Cumming or myself at any place to the northward of their outcrop, but I have found an agglomerate on Bradda Head resembling those of Scarlet.

These facts justify the inference that the transport of boulders was from N.E. to S.W., with very little deviation on either side ; and it points to the operation of land ice, as marine ice could not act with such regularity.

II.—"ASPECT OF THE CRAGS."

The smooth, moutonnée appearance of the north-easterly slopes of the Manx hills and the relative roughness of the south-westerly faces, features which have no reference to the structure of the bed-rocks, corroborate the other evidence of ice-movement.

III.—THE SURFACE FEATURES OF THE DRIFT DEPOSITS.

These, in the South of the Island at least, are indicative of the action of land ice moving from the N.E. Drumlins and Eskers have there a general N.E. and S.W. trend. The Drift-hills of the North are not easy of interpretation, but their configuration and composition alike negative the idea of marine origin.

IV.—THE GLACIAL STRIÆ.

The Striæ observed at four localities in the South of the Island range through 35°—viz., from "W. 27° S. to S. 28° W. (otherwise from S. 63° W. to S. 28° W.), a total deviation of only 35°, *being less by 2½° than the angle between two superposed sets of striæ observed by me on a roche moutonnée in front of the Gorner glacier.*" Towards the middle of the Island, on South Barrule, I observed striæ running towards S. 4° or 5° E. These facts I consider to justify Mr. Hewitt's conclusion, that "this kind of action could only be caused by a sheet of land ice."

A case of disturbance of the clay slate, which appeared to have been caused by an agent acting at right angles to the main direction, I regard as of no importance, as the phenomenon was on a very small scale, and probably due to local causes.

Other striæ in the North of the Island will be mentioned in the sequel.

V.—THE ORIGIN OF THE FOREIGN BOULDERS.

These consist for the most part of granites from the Southern Uplands of Scotland, with flints from beds, marine or fluviatile, which may in their ultimate origin be Irish, but whose proximate origin (the only fact of importance in this connection) cannot be ascertained. A very small number of Lake District rocks are found, a few granites, possibly of Irish origin, many pebbles of Eurite from Ailsa Craig, and one example of the Pitchstone of Arran. It is especially noteworthy that no rocks from any locality (*e.g.*, Wales) to the Southward of the Isle of Man have ever been discovered.

VI.—THE DRIFT DEPOSITS.

These are roughly divisible into two categories:—

1.—*The High-level Deposits*, consisting for the most part of slate-coloured clay, crowded with well-scratched local stones. This deposit mantles all the hills, and accounts to some extent for their smooth outlines. In the Southern half of the Island a few foreign stones occur at high-levels, but in the Northern hills I found not a single example.

2.—*The Low-level Deposits.*—These consist, in the North of the Island, of stony boulder-clays and beds of sand and gravel. The whole series contains marine-shells, usually in a fragmentary condition ; but at Shellag Point a small patch of clay, without stones, yielded paired valves of *Leda minuta.* In Glen Mooar (Kirk Michael) a bed of clay, like that of the high-level series, is found to inosculate with the ordinary shelly boulder-clays and sands ; and in the cliffs to the southward of the Glen Mooar a tongue of clay of the high-level type occurs in the midst of a bed of shell-bearing sand, and at the first exposure of live-rock in the cliffs a slaty rubble underlies the low-level series. A remarkable section on the East coast at Ballure, where the clay slate emerges from beneath the Drift, shows features bearing some resemblance to the last. In the South of the Island the deposits are of a somewhat different character, being liable to considerable variation of texture according to the nature of the subjacent rocks. Shell-fragments are decidedly rare.

VII.—PALÆONTOLOGY.

I enumerate 81 species and varieties of Mollusca from the Drift of the north. Of these, seven are restricted in recent seas to regions to the northward of Britain, 17 are British and northern, three range from British seas southward (but not northward), and *no fewer than eight species are extinct.* I describe and figure a new species, *Nassa Kermodei.*

VIII.—THEORIES.

The section bearing this heading gives a summary of the views of my predecessors in this field of research, and my own explanations and conclusions. Regarding the persistent N.E. to S.W. transport of the Foxdale granite and its remarkable uplift, I point out how entirely inconsistent this is with the supposition that floating ice played any part in their dispersal. Simple deductions are drawn from the N.E. to S.W. trend of the drift-mounds and the striæ. The apparent total absence of foreign erratics on the high ground of the north, despite the great thickness and extent of the Drift deposits, I consider to be inexplicable upon the submergence theory. I suggest, in explanation of the phenomena, that the Isle of Man was glaciated by *ice-sheet* ice, which carried most, if not all, its rocky burden in its lower strata ; that the lower portion cleft against the precipitous front which the hill-country presents to the northward (just as glaciers cleave against steep rocks which confront them) ; and only the clean upper layers passed on to glaciate the hills with their own *debris.* I find confirmation of this theory in the fact that foreign boulders occur over the tops of the Maughold hills, and also in a remarkable series of striæ discovered by Mr. Harrison subsequently to the promulgation of my theory. These striæ show very remarkable deflections in the neighbourhood of Ballure and Port Lewaigue. I explain the Glen Mooar section by changes in the place of cleavage of the ice, and in its direction of onset. The Eskers I regard as silted up channels of subglacial rivers.

The evidence of the shells in the Manx Drift is opposed to the theory of deposition beneath the sea. I regard them as relics of shell-beds of different geological ages, which have been involved in the basal moraine, or in the ice itself, and re-deposited either in the unassorted boulder-clays, or in the washed sands and gravels. A stoneless shelly clay, containing a purer fauna and better preserved, may be a transported mass of the sea-bottom.

The total absence at high-level in the Island of sea-worn caves and cliffs, of sea-beaches and of rocks bored or encrusted by marine creatures, is another and final proof that marine action played no part in the formation of the Manx Drift.

IX.—POST-GLACIAL HISTORY.

A submerged forest has been found at several places on the south coast, pointing to a post-glacial elevation of the land. The study of the existing fauna and flora, however, shows that the elevation was probably of very small extent and brief duration. Raised beaches, indicating a contrary movement, have been found at elevations not exceeding 20 feet above the present level of the sea.

CONCLUSIONS.

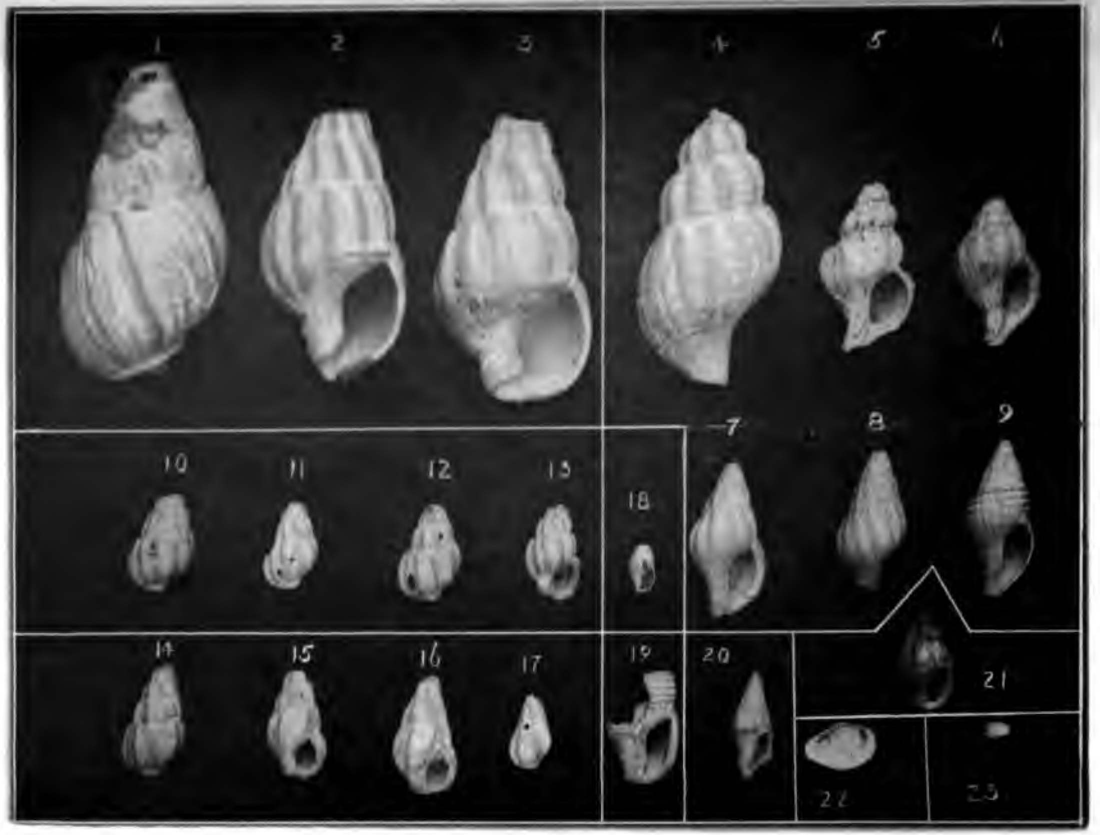
The principal conclusions which are, I think, established are :—

1. That the glaciation of the Isle of Man was effected by moving *land ice*, which overtopped its highest mountain (Snaefell, 2,034 feet).
2. That the general movement was from north-east to south-west, with oscillations of 15-20° on each side of the mean.
3. That local deviations were produced by local physical features.
4. That the lower stone-laden ice was cleft by the bold front of the hills south of Ramsey, and was deflected right and left, producing the divergent striæ.
5. That neither during nor since the Glacial Period did marine action play any part in the history of the Isle of Man except at the small elevations indicated by the post-glacial beaches.
6. That any post-glacial elevation must have been of small extent and brief duration.

Brown & Son, Printers, "The Isle of Man Times" Office, Douglas.

REFERENCE TO FIGURES.

1—3	Nassa serrata, Broc.
4—9	Fusus Forbesi, Strick.
10—13	Nassa Monensis, Forbes.
14—17	N. Kermodei, sp. nov.
18	Columbella, sp.
19	C. sulcata, J. Sow.
20	Mitra sp.
21	Nassa, sp. nov. (Mr. Praeger's specimen)
22	Nuculana minuta, Müll.
23	Yoldia pygmæa, Münst.


1
2
3
4
5
6
7
8
9
10
11
12
13
18
14
15
16
17
19
20
21
22
23

F

F